



CAPSTONE PROJECT **PROPOSAL**

Title: **BinHero: An AI-Driven Smart Waste Disposal Mobile App with Object Detection & Motion Tracking**

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GENERAL INFORMATION

Project Title: BinHero: An AI-Driven Smart Waste Disposal Mobile App with Object Detection & Motion Tracking

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Group Number: 2

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ABSTRACT

1 EXECUTIVE SUMMARY

In today's rapidly urbanizing world, effective waste management remains a critical challenge, with inefficient disposal methods contributing significantly to environmental degradation and public health concerns. The fast pace of urban development has led to rising waste output across the world at 2 billion metric tons per year and forecasts predict this number will increase by 70% by 2050 (World Bank, 2018). Despite efforts to improve waste infrastructure, behavioral gaps persist; studies indicate that 30–40% of recyclable materials end up in landfills due to user negligence or lack of accessible bins (Xu et al., 2022). Moreover, traditional waste management systems often lack public engagement, leading to inefficient recycling rates and littering. These systemic gaps highlight the need for solutions that merge infrastructure visibility with behavioral nudges. Gamification and technology-driven solutions have emerged as effective tools to incentivize behavioral change, as evidenced by studies showing that interactive apps increase user participation in sustainability practices by up to 40% (Johnson et al., 2016). These insights provide a strong contextual foundation for the necessity of innovative solutions like the **"BinHero"**, which address both infrastructural visibility and user engagement in waste management.

BinHero aims to transform waste disposal into an interactive, community-driven experience by integrating AI, gamification, and crowdsourcing. Unlike conventional waste management apps that focus solely on bin locators or educational content, this project uniquely combines real-time object detection, motion tracking, and sound analysis to validate disposal actions, while fostering competition and collaboration through PvP challenges and team-based tasks. By leveraging gamified mechanics, the app aligns with behavioral theories suggesting that immediate feedback and rewards significantly enhance pro-environmental habits (Hamari et al., 2020). This dual focus on technological precision and social engagement positions the app as a novel tool to bridge the gap between awareness and action. By merging technological validation with social incentives, the app aims to create measurable behavioral and infrastructural impact.

The anticipated outcomes of this project include the development of a robust, user-friendly mobile application that effectively encourages responsible waste disposal through rewards, points, challenges, and social competition. Beyond improving individual disposal behaviors, the app is expected to generate a valuable, crowdsourced dataset of bin locations that can aid urban planners and local governments in optimizing waste management infrastructure. Ultimately, the

project aims to deliver a scalable solution that not only addresses pressing environmental issues but also cultivates a community of environmentally conscious citizens dedicated to sustainable living.

2 RELATED WORK

3 PROJECT PURPOSE

3.1 Problem Statement

Global waste generation is accelerating due to rapid urbanization, yet existing waste management systems fail to engage citizens in proper disposal practices. Research indicates that 30–40% of recyclable materials end up in landfills due to a lack of accessibility and user negligence (Xu et al., 2022). Despite ongoing improvements in waste infrastructure, behavioral inertia remains a critical barrier, with traditional systems lacking real-time validation and motivation mechanisms to ensure proper waste disposal.

Conventional waste management approaches do not leverage behavioral science to drive engagement, leading to persistent littering and inefficient recycling. To bridge this gap, there is an urgent need for a solution that integrates real-time AI-based validation, motion tracking, and gamification—transforming waste disposal from an obligation into an interactive, community-driven practice. This gap underscores the urgent need for innovative solutions that merge real-time technological validation with behavioral nudges to transform waste disposal into an actionable, community-driven practice.

3.2 Project Objectives

- ➔ **Enhance User Engagement in Waste Disposal:** Implement gamification techniques such as PvP challenges, rewards, and leaderboards to encourage users to adopt responsible waste disposal habits.
- ➔ **Integrate AI for Real-Time Waste Validation:** Utilize object detection and motion tracking to verify correct disposal actions, ensuring real-time feedback and reducing improper waste segregation.

- ➔ **Optimize Accessibility of Waste Disposal Bins:** Develop a crowdsourced bin location database that helps users easily find nearby waste disposal points, contributing to better waste infrastructure planning.
- ➔ **Promote Community Participation in Sustainability Efforts:** Foster a collaborative, eco-conscious community by integrating team-based waste challenges and public leaderboards to drive participation.
- ➔ **Reduce Landfill Contributions Through Behavioral Change:** Encourage users to properly sort recyclable materials, reducing the 30–40% of recyclables that currently end up in landfills due to negligence (Xu et al., 2022).

3.3 Proposed Functionality And Solutions

❖ **Recognition and Waste Disposal Detection**

Problem: Most of the people are confused by understanding whether waste is recyclable or not, which causes them to waste their time by putting the waste in the wrong place.

Solution: The AI powered object detection application provides a waste classification to help users to dispose of his waste to correct bin use motion tracking to ensure users eliminate trash correctly and then the scoring system rewards collection of trash in the right bin.

❖ **Game Like Points and Challenges**

Problem: People are not really inspired to deal with their waste in the normal sense and therefore have very low follow-ups in disposing of trash brought from home.

Solution: Gamifying waste disposal through points system and leaderboards combined with daily and weekly challenges makes waste disposal a fun and competitive activity. Users earn points for throwing their trash in the right bin, and also for bonus activities like adding bins and referral of others to the app.

❖ **Team and PvP Modes**

Problem: Waste management is considered a personal responsibility; hence communal involvement in making it sustainable is lacking.

Solution: It provides integrated features for team challenges and real-time PvP, so the user can work with other users or compete together in doing waste disposal activities which is fun and engaging too. This way, social interaction happens, and this causes community engagement and collective responsibility for the environment.

❖ **Crowdsourced Bin Locations**

Problem: Improper bin placement also leads to users having less nearby options to dispose of used items and results in littering.

Solution: Users can voluntarily add and validate the locations of waste bins, thus establishing a live, crowdsourced map about waste bins. Moreover, this feature helps users find the places for trash disposal and encourages them to contribute via a reward system.

❖ **Rewards and Achievements**

Problem: If no inducements are made, then people will not take interest in having healthy habits of waste disposal.

Solution: Badges, trophies, and event-based rewards are given for contributions made by users. Progress tracking also ensures that users remain occupied and motivated for practicing proper waste disposal habits.

❖ **Mobile App, Real-Time Functionality**

Problem: Waste management solutions of the past were completely digital and had no real-time impact on their audience with respect to engagement and viability.

Solution: The software, built in React Native for smooth user experience is powered by Node.js and Express for back-end data management. MongoDB holds data relating to user activity, locations of the trash bins, and leaderboards, while Socket.IO provides real-time updates on challenges and PvP contests.

❖ **Community Awareness Features**

Problem: Many users are ignorant regarding the methods of appropriate disposal of waste materials and the concepts of environmental sustainability.

Solution: The app will be an educational insight into waste management, sharing socially about achievements gained through the app, and the integration of special events for schools and communities. All this will help in spreading awareness and encourage responsible habits in waste disposal.

4 ASSUMPTIONS

The development of the BinHero app is based on a number of fundamental presumptions that concern's on technical viability, user behavior and adoption, the efficacy of gamification techniques, and the application's long term viability form the basis of its creation. And, these presumptions are essential in order to determine how the system is designed, implemented and what outcomes are expected from the system.

4.1 Technical Assumptions

- ★ It is assumed that the AI powered object detection system will reliably differentiate between materials that are considered as garbage and those that are not, as well as classify waste into biodegradable and non-biodegradable categories. This assumption is supported by developments in Deep Learning and Computer Vision, where the models are trained on a variety of representative datasets that can improve the reliability as well as accuracy.
- ★ The project speculates that motion tracking feature would reliably and consistently identify and is able to interpret hand movements, assuring the system's capacity to confirm effective garbage disposal with minimal occurrence of negatives or false positives.
- ★ It is expected that the program will run on most of the modern smartphones with cameras without any hassle, ensuring widespread availability.
- ★ While offline capability might be accessible for core disposal tracking however, features like leaderboards, bin location verifications and data synchronization are presumed to require internet connection.

4.2 User Behaviour Assumptions

- It is expected that users will be motivated to participate in the gamified garbage disposal activity since gamification has proven to be effective in boosting users' engagements.

- It is assumed that users will actively contribute and provide bin location information, which will allow the crowdsourced map to grow and improve its dependability as a resource.
- The expectation that users would accurately and fully confirm bin placements maintains the validity and reliability of the location-based dataset.
- Camera permissions are necessary in order to enable AI-based detection. Therefore, it is expected that users will be willing to grant them.

4.3 Implementation and Sustainability Assumptions

- ➔ It is assumed that the program will be scalable and will be able to handle increase in users and bin location submissions without suffering from noticeable performance issues.
- ➔ The app's gamification techniques are thought to have a positive impact on waste management practices, encouraging ecological responsibility and lowering littering.
- ➔ With continuous updates, challenges and rewards , it is anticipated that users' involvement will be maintained .
- ➔ The backing of local governments and academic institutions is assumed to have an impact on the application's success.

4.4 Gamification and Community Assumptions

- ❖ It is assumed that implementation of points based systems will improve the user engagement and encourage the users to regularly involve in garbage disposal.
- ❖ Player-versus-player (PVP) challenges and leaderboard rankings are considered to encourage a healthy rivalry among players which will ultimately boosts the motivation and involvement
- ❖ Team-Based challenges are thought to foster a sense of community and increase collaboration that will result in higher participation.

5. PROJECT DESCRIPTION AND SCOPE

5.1. Project Description

5.1.1 Project Approach

The BinHero App is meant to transform waste disposal habits through the use of AI, gamification, and crowdsourced mapping. The app leverages real-time AI object detection and

motion route tracking to detect disposal and validate disposal actions while challenging users to win rewards and to contribute to mapping the locals of trash bins. The application aims to combine technology and the users' engagement in promoting responsible waste management in a very fun and engaging way.

5.1.2 Specific Solution

Multiple innovative features are employed to make sure that app provides seamless experience:

- ★ **AI-Powered Object Detection:** The smartphone camera identifies litter and nearby bins.
- ★ **Motion Tracking:** It checks whether disposal was accurate by tracking hand motion and sound detection.
- ★ **Gamification Elements:** Users gain points for proactive disposal, bin location input, and various challenges.
- ★ **Leaderboards and Rewards:** Facilitates PvP, team challenges, and merit-based rewards, fostering friendly competition.
- ★ **Crowdsourced Bin Location Map:** A real-time map of bin locations built on user input and confirmation.

5.1.3 Target User

The BinHero App is targeted towards:

- **General Public:** Anyone willing to play their small part toward a cleaner environment with fun and gamified litter disposal.
- **Students & School:** The institutions will use it for interactive teaching of environmental responsibility.
- **Communities & Municipalities:** Local governments that want to improve the waste disposal landscape and keep people clean.
- **Event Organizers & Business:** Organization for those that would like to handle the event/office waste sustainably and in a fun and engaging manner.

5.1.4 Benefits

- **Promoting Responsible Waste Disposal:** Profit with fun and rewarding activities ensures that people develop good habits to dispose of waste responsibly.
- **Enhancing the Cleanliness of the Public:** Puts the bins on everybody's radar so as to reduce littering and involve them in cleanup.

- **Enhances the Community Engagement Aspect:** Involves teamwork, competition, and a sense of accomplishment via personal achievements, leaderboards and challenges.
- **Creates Reliable Bin Maps:** Aids users in locating the nearest bins, thus reducing the chances of improper waste disposal.
- **Supports Municipal and Environmental Initiatives:** Connects to efforts being made by government and NGOs to promote sustainable waste management practices.

5.2 Scope

5.2.1 Coverage

The BinHero App aims to bring forth a very interactive and gamified solution for waste-disposal concerns with inclusion of multiple innovative features below:

- ❖ **Trash Disposal Verification:** AI-based detection and motion tracking assure the disposal of trash is done correctly.
- ❖ **Gamified Rewards System:** Points, badges, and ranks are awarded to users based on their waste disposal activity and other related activities.
- ❖ **Crowdsourced Bin Locations:** Allows users to add and verify bin locations as live constructs to create the best map.
- ❖ **Social Engagement Features:** Engagement occurs through PvP and team-based challenges.

5.2.2 Platform Features and Modules

i. Client-Side Functionality

- Authentication and profile management concern the secure tracking of users' points.
- AI-based detection of trash and its type using cameras.
- On-Device AI for Trash Detection & Motion Tracking to ensure real-time, low-latency processing.
- Verification of disposal accuracy with motion tracking.
- Gamified scores, leaders, and achievements.
- Social engagement through team challenges and PvP competitions.
- PvP Matches: Fastest Player or player with most points wins(Specific game design will be discussed during the development).

- Team Challenges: Users can form teams, compete in waste disposal tasks, and add bins for community clean-up activities.
- Interactive mapping of bins, locations added by users.

ii. Server-Side Functionality

- User data, points, and bin locations are stored securely with proper security measures.
- Register and Login Functionality.
- Real-time multiplayer PvP and team matches through WebSockets (using Socket.io).
- Game State Management to track your on-going matches, action by players, and scoring.
- Gamification system for point calculation, leaderboard updating, and progress in challenge completion.
- Real-time mapping for geolocation and bin discovery.

5.2.3 User Roles

i. General Users

- ★ Points can be accumulated when trash is disposed correctly and other related challenges are completed like addition of new bins in the map, referrals, daily challenges.
- ★ Participate in individual and team-based challenges.
- ★ Real-time maps showing bin locations may be implemented to enable easy detection of disposal sites.
- ★ View and compete on the leaderboard.

ii. Verified Contributors

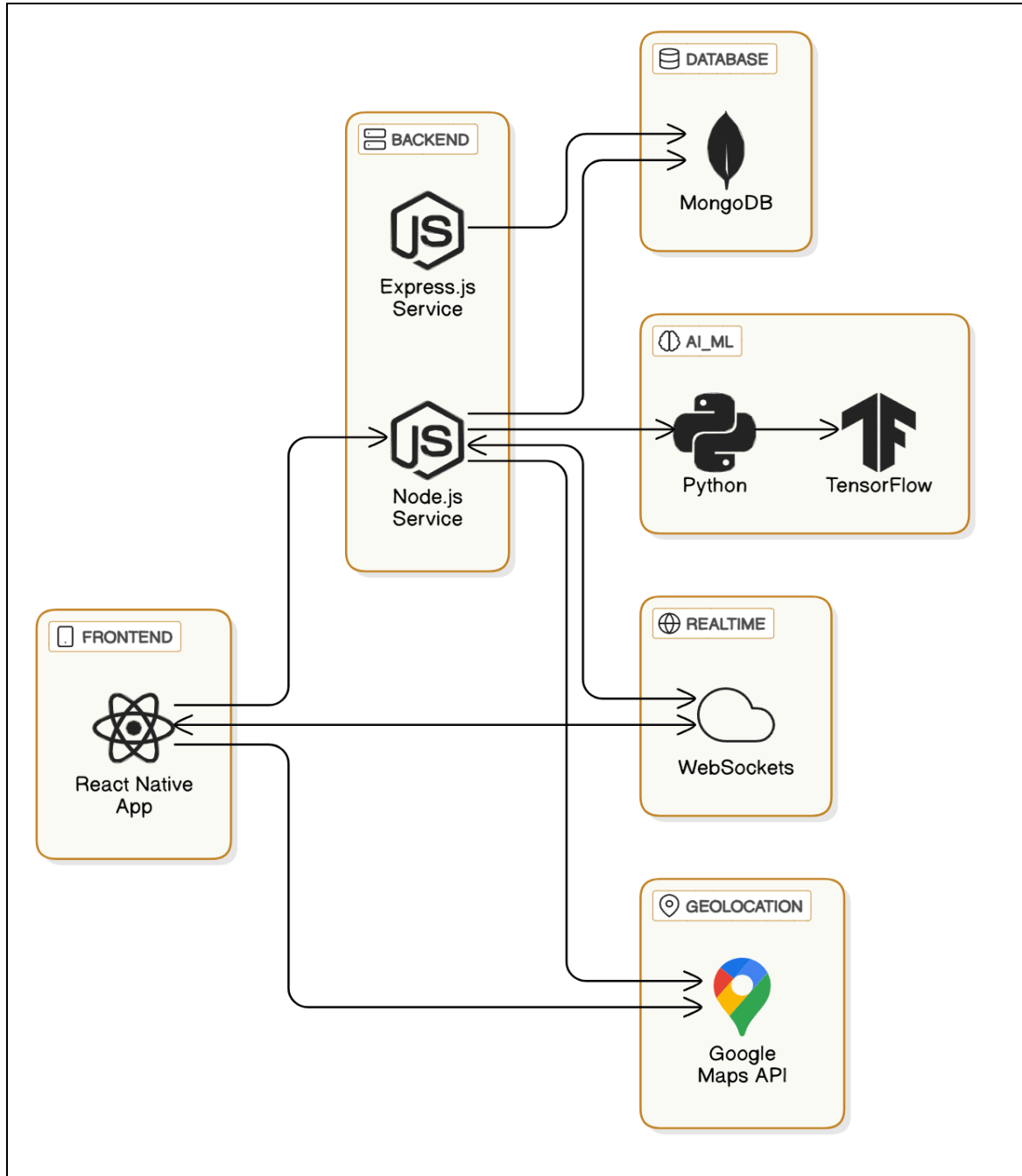
- ❖ Verify the bin location submitted by other users to ensure accuracy.
- ❖ Extra rewards can be obtained for high-quality contributions.
- ❖ Challenge and game modes can be recommended.
- ❖ Can also play as a regular or general user.

iii. Administrators & Moderators

- ☐ Monitor activity by all users and flag fraudulent contributions.
- ☐ Managing the leaderboard and setting up challenges to compete on.
- ☐ Verifies the exact location of bins and approves submissions.

5.2.4 Technologies

- **Frontend:** React Native for cross-platform mobile application development and building a functioning UI.
- **Backend:** Node.js with express on necessary backend services required for the mobile application.
- **Database:** MongoDB for storing user profiles, points, and locations of the bins.
- **AI & ML:** Python and tensorflow will be used as the base technology, the rest of the libraries and frameworks will be decided later.
- **Real-Time Multiplayer:** WebSockets for PvP as well as team match synchronization.
- **Geolocation Services:** Google Maps API for bin location tracking as well as user navigation.



5.2.5 Project Goals

- Promote responsible waste disposal through interactive and gamified experiences which can be fun and engaging.
- Create an accurate crowdsourced bin location map to assist with waste management.
- Foster community engagement through team challenges and competitive gameplay in a fun and a very engaging manner.

- Support municipalities and organizations in their waste management activities.

5.2.6 Confines and Limitations

- ❖ **Internet Dependence:** While on-device AI decreases reliance on the internet, certain functions like leaderboards, bin mapping, and cloud AI fallback, still require active internet access.
- ❖ **Device Compatibility:** Older or low-end devices may have performance issues in real-time AI processing hence requiring users to enable cloud-based fallback processing which is dependent on the internet.
- ❖ **Accuracy Limitations:** On-device AI model accuracy may be compromised in most of the low-light situations or with strange trash items, necessitating an API for checking.
- ❖ **User Participation Dependency:** For an early stage, the crowdsourced bin map may have been provided with very few bin data until the community grows.
- ❖ **Privacy Concerns:** Users may be required to provide camera and location permissions, which, being a great concern for privacy, has to be clearly defined in the policies and safeguarded.

6 MANAGEMENT MILESTONES

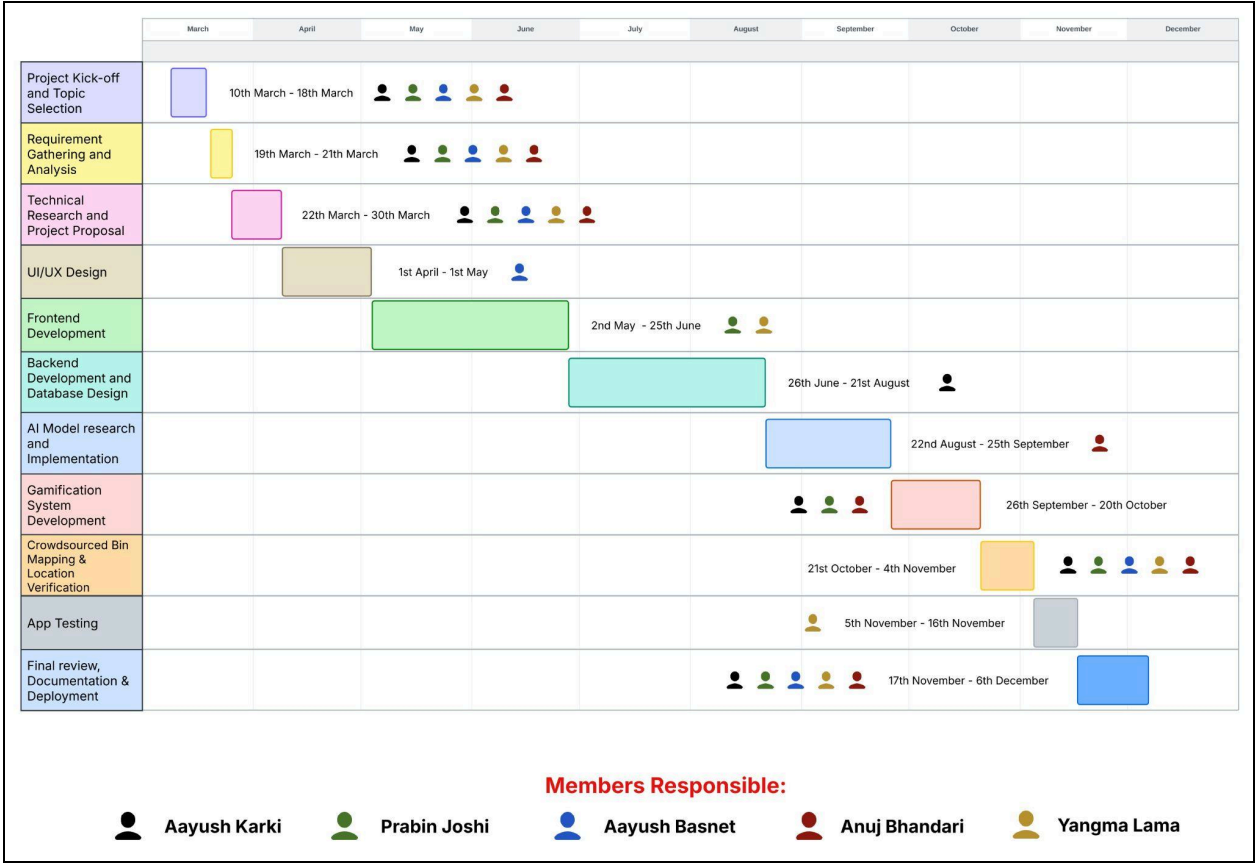
All the important phases, members responsible, milestones that are necessary for succeeding the application's development are mentioned as project work plans. They serve also to monitor progress, allocate resources properly and ensure timely delivery. The tasks have been divided into several stages. The reason for that is to ease planning and teamwork. In the below table, it displays the major milestones, responsible members, and the estimated timeline.

No.	Milestone	Person Responsible	Expected Duration (Days)
1	Project Kick-off and Topic Selection	Entire Team	10
2	Requirement Gathering and Analysis	Entire Team	10
3	Technical Research and Project Proposal	Entire Team	10
4	UI/UX Design	Aayush Basnet	25

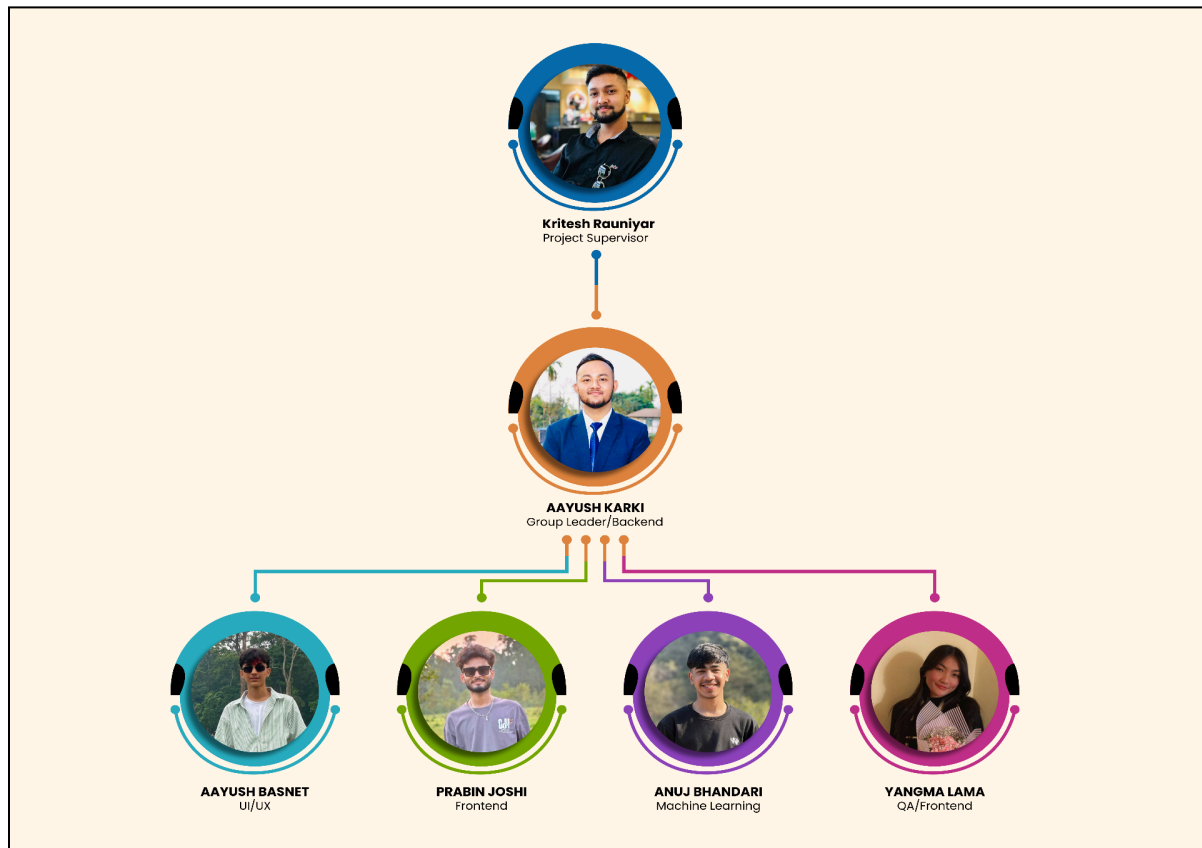
5	Frontend Development	Prabin Joshi Yangma Lama	55
6	Backend Development and Database Design	Aayush Karki	55
7	AI Model research and Implementation	Anuj Bhandari	35
8	Gamification System Development	Aayush Karki Anuj Bhandari Prabin Joshi	25
9	Crowdsourced Bin Mapping and Location Verification	Entire Team	12
10	App Testing	Yangma Lama	15
11	Final review, Documentation & Deployment	Entire Team	20

The following Gantt chart displays project timing as well as significant achievement goals and personnel involvement in all assignments. The visual display summarizes project duration and progress progression in a simple manner. The chart ensures efficient cooperation and helps in monitoring progress of major tasks.

Group Proposal - Group 2



7 PROJECT ORGANIZATION



7.1 Organization Description

The project team consists of five committed members, each specialising in a particular field to provide an organised and efficient development process. The organized structure accelerates teamwork and establishes specific tasks for team members who possess adequate qualifications to handle each project section. Through the combination of various skill sets, the team intends to create an excellent system that fulfills the project's goals.

The projects organization involves the following key roles:

- a) **Project Supervisor:** The project monitor role involves the supervisor to check that schedule tasks remain on track. They give direction, monitor development, give feedback, approve major decisions and help the group leader in leading the team and overcoming obstacles.
- b) **Group Leader:** Within the role of primary project leader the Group Leader directs workflow management activities and works to build unity among team members. The Group Leader allocates tasks to team members while sustaining ongoing communication

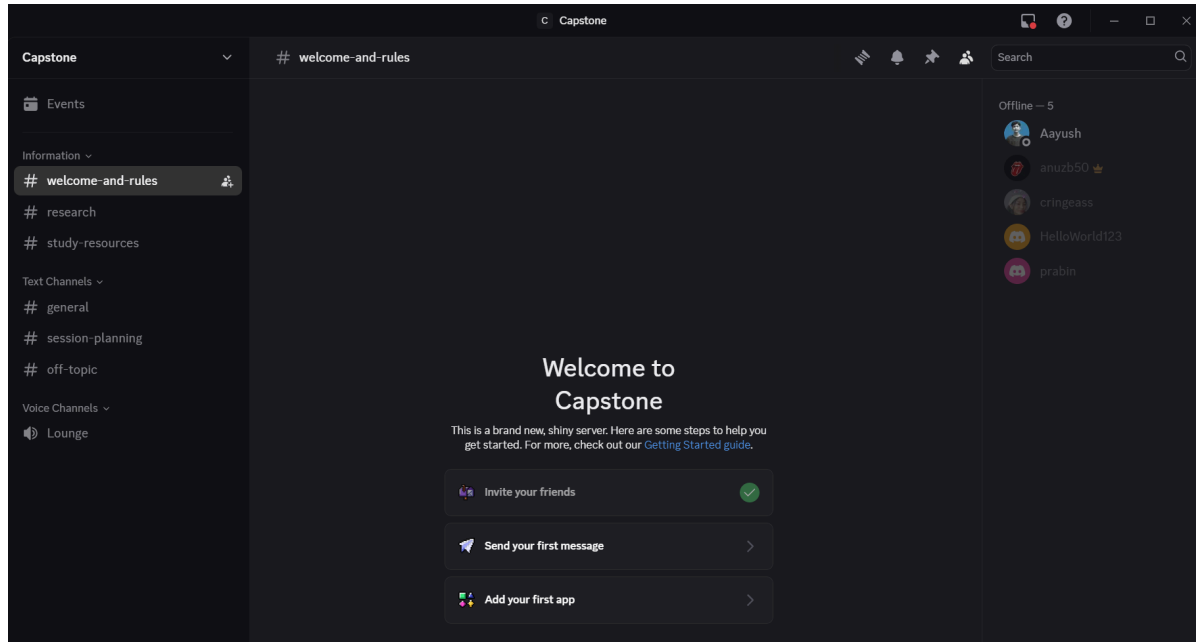
with the supervisor to ensure project growth.

- c) **Group Members:** Each member of the project team is committed to a separate aspect of the project and contributes different types of skills to the group. Users function as a team to achieve task efficiency and system completion.

7.2 Communication Plan

An effective project depends on strong communication to achieve both efficient problem-solving approaches and transparent work responsibilities assignment and smooth team interaction. For meetings, discussions, and daily interactions, the project will use Discord as the main communication platform for smooth teamwork. For official communication and version control, additional tools like GitHub and email will also be used. The communication plan consists of:

- a) **Regular Meetings:** Under the authority of the Group Leader, weekly meetings will be held via Discord to discuss issues, plan future work, and discuss progress. Meetings occur based on organizational demands.
- b) **Progress Reporting:** Team members will give the Group Leader progress reports, which the Group Leader will then gather and report to the Supervisor.
- c) **Formal Communication:** The group uses Discord to conduct fast meetings coupled with casual talks yet depends on email to handle official decisions and documents.
- d) **Version Control:** The platform will use GitHub for version control, code administration and to support team development among programmers.



Furthermore, jira was used by the group to effectively keep track and manage the development of the app. Organizing tasks, setting priorities, and facilitating smooth operation of the teammates tasks among them was one of the benefits it provided. Jira helped us to avoid delays and communication by categorizing work into Done, In Progress, To-Do and Upcoming Tasks. This made it easier to track progress, adjust plans and know that every stage of research to development is being carried out professionally.

7.3 Roles and Responsibilities

For the project to be completed successfully, each team member is crucial. Their tasks and responsibilities of each members are described in detail below:

Fullname	Roles	Responsibilities
Aayush Karki	Group Leader, Backend Developer	Keep an eye on the progress of the project to ensure smooth progress and cooperation. Be the main link between supervisor and members and assign tasks. Work on the design of the database to satisfy project needs and integrate the backend.
Aayush Basnet	UI/UX Designer	Design visually appealing as well as simple

		wireframes and mockups so that they can be used by users easily. Help frontend developers get them to execute design components accurately. Carry out user research to gather feedback and use it to improve consistently.
Anuj Bhandari	Machine Learning	Integrate AI models into the project development research. Get high accuracy for train and test machine learning models. Work seamlessly with the backend team for perfect AI using. Analyze data patterns to optimize AI algorithms.
Prabin Joshi	Lead Frontend Developer	Build the user interface according to UI design requirements. Makes animations and other interactive features, and increases the user experience. For better efficiency, improve frontend performance. Pay attention to accessibility and usability, so the app will be intuitive to all users.
Yangma Lama	QA & Frontend Support	Provide support in UI implementation and frontend solutions. Test all of the project components extensively. Confirm system performance and the functional requirements. Make sure defects are documented and reported correctly.

8 RISK ANALYSIS

8.1 Risk List

- a) **Inaccurate AI Detection & Motion Tracking:** AI powered object detection and motion tracking can wrongly identify the trash or bins and in this case lead to false positives or negatives. Users may become frustrated and become less involved if their activities are not correctly detected.
- b) **Low User Engagement & Retention:** The lack of active rewards, interesting challenges

and easy in use interface can put the users off from the software. Without new updates with engaging features and rewards, the user base can also start to decrease over time.

- c) **Incorrect or Fake Bin Locations:** Here, the reliability of the crowdsourced bin map can be reduced if users either intentionally or accidentally make mistakes about the bin locations they input. Users who depend on precise data for garbage disposal may become frustrated as a result.
- d) **High Server Load and Scalability Issues:** The server may be overwhelmed by fast user growth resulting in slow response time, crashes in the system, or the entire system failure. The application may perform poorly, without optimisation and without cloud based scaling options.
- e) **Hardware Compatibility Issues:** App performance might be poor on older, outdated or low processing power smartphones which can affect the user experience. Crashes or performance problems may occur on low end devices if the application uses many resources.
- f) **User Adoption Risk:** It may be challenging to promote the app's widespread use, especially in areas with low digital literacy and lack of interest from the public regarding gamification of garbage management. The app might have trouble attracting and keeping an engaged audience in the absence of partnerships, rewards, and efficient marketing.

8.2 Mitigation Strategies

a) Inaccurate AI Detection & Motion Tracking:

- To increase their accuracy AI models must be continuously refined and improved on by using a number of data sets.
- Update the AI models reported by the users that are providing inaccurate detections.
- If a detection is wrong, provide customers with alternate input choices or provide manual validation.

b) Low User Engagement & Retention:

- Introduce various competitions such as seasonal competitions or streak based awards and daily challenges to maintain the users interest.
- Make sure that the UI/UX design is far engaging and easy to use so it can guarantee a seamless user experience.

- Social media integration and push notification will encourage and remind the users.

c) Incorrect or Fake Bin Locations:

- Give users a way to report or highlight incorrect bin placements as part of a verification process.
- Increase the credibility of trash cans that are regularly used or have been validated by the community.
- Use AI in location analysis and GPS validation for flagging doubtful bin locations.

d) High Server Load and Scalability Issues:

- Install cloud-based hosting programs that can scale automatically.
- Encourage the use of caching techniques that help reduce duplicate requests to increase the app speed.
- To be sure that the system handles growing traffic, keep doing routine load testing.

e) Hardware Compatibility Issues:

- Make the app easier to use on daily hardware configurations by testing in on various devices.
- Provide performance settings that can be set to low power and limited AI modes for smoother operation.
- Change the graphics and AI processing to give performance for different device capabilities.

f) User Adoption Risk:

- Conduct awareness campaigns in public areas, communities, and schools to encourage adoption.
- The app can be marketed through collaboration with local governments, influencers and the environment groups.
- Reward in app awards and bonus for referrals to get users to refer others.

8.3 Risk Matrix Table

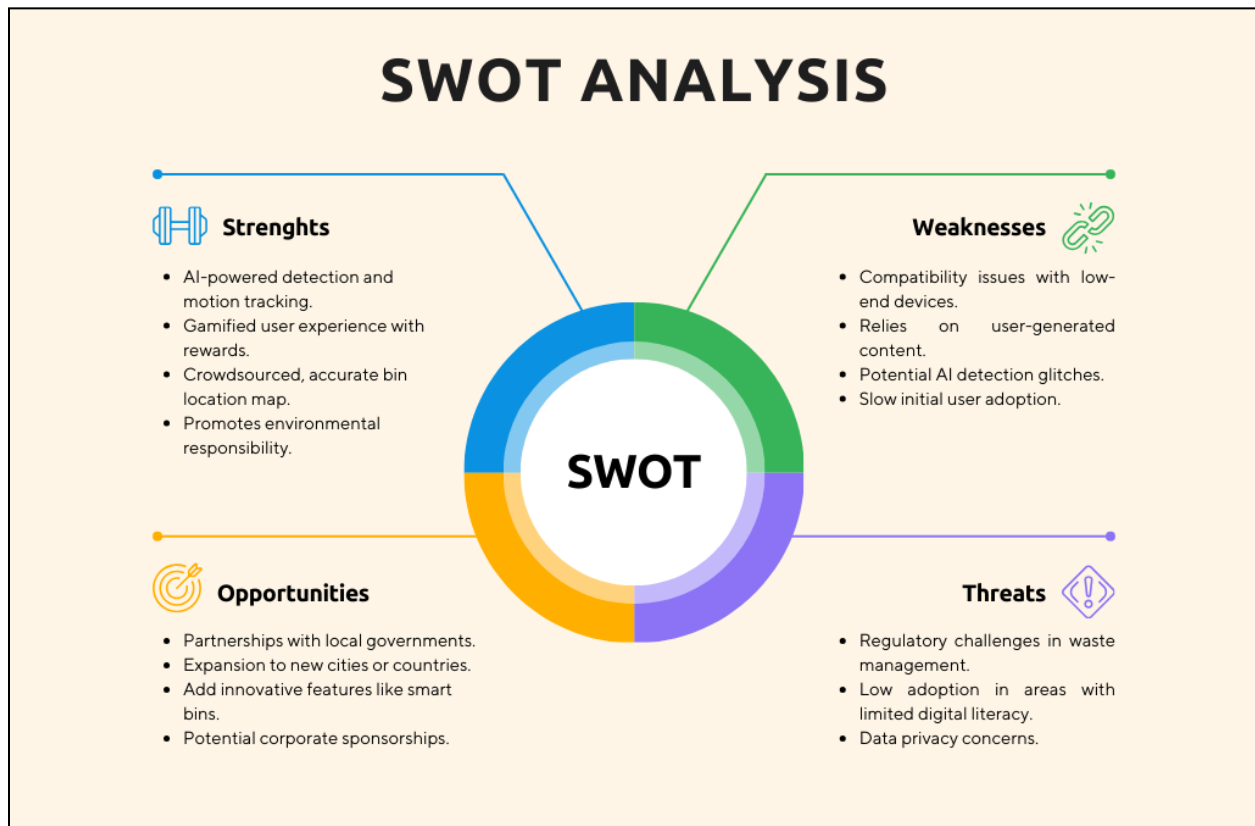
Risk Category	Likelihood	Impact	Risk Level	Mitigation Strategy
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Inaccurate AI Detection & Motion Tracking	Medium	High	Critical	Train the AI Models, implement the feedback systems and offer manual validation.
Low User Engagement & Retention	Medium	High	High	Bring on more challenges, freshening up the UI/UX, and use notifications and rewards to enhance the users.
Incorrect or Fake Bin Locations	High	Medium	Moderate	Implement verification, GPS validation, and user-based bin location rating system.
High Server Load & Scalability Issues	Medium	High	Critical	Host on the cloud, smoothen the app performance, do loads testing.
Hardware Compatibility Issues	Medium	Medium	Moderate	Support graphically adapted processing, test on other hardware, provide different performance settings as well as optimize graphics and AI processing.
User Adoption Risk	Low	High	Critical	Reward referrals, do partnerships & conduct awareness campaigns.

The main risks regarding the application's development are described thoroughly in table 7. It sorts out risks according by their overall risk level, impact and likelihood. Ranked high priority risks include high server load and scalability issues, inaccurate AI detection and motion tracking, and risk of adoption for the user. These risks could most significantly impact the performance of the app and the user engagement. Low User Engagement and Retention, as well as wrong or fake bin locations are moderate risks. But they are vital, and they can be solved by the implementation of techniques such as user verification systems, gamification and better UI/UX.

8.4 SWOT Analysis

Following is a SWOT analysis of the Bin Hero App as shown in the table below. It also helps to consider the strengths, weaknesses, opportunities and threats of the app. This analysis helps to understand the external and the internal factors which might impact on the performance of the app. Identifying critical strengths, areas for development, possibilities for growth and external risks, the SWOT analysis gives valuable information that should come handy in strategic planning and decisions.



9 FUTURE WORK

Future advancements should concentrate on few crucial improvements in order to guarantee the long term viability and expandability of the application. These enhancements will focus on expanding the system's applicability and increasing users involvement alongside maximizing system performance.

- **Improved waste classification and AI accuracy:** The future versions of the application will incorporate various cutting-edge deep learning models that have been trained with more variety of sample custom datasets. The system can support ongoing model

improvement while also protecting user's privacy by utilizing federated learning techniques. Decentralized data processing will be made possible through this strategy. This approach will lessen the dependency on centralized storage and reduce the possible security issues. Through continuous refinement of the classification algorithms will definitely boost the reliability and efficiency of waste sorting, as well as ensuring adaptation to various waste categories.

- **Augmented Reality (AR):** The system can expanded with Augmented reality inorder to increase user involvement and also encourage proper waste segregation. With the use of this feature, users will be allowed to utilize their cameras on their smartphones to scan waste materials, causing realtime AR overlays to appear that will visually indicate which disposal container is best. This feature will provide an easy to use and interactive approach to waste classification . Moreover, the accessibility and educational values of garbage disposal will undoubtedly be enhanced through the application of AR technology, specifically in urban regions where waste management laws may differ.
- **AI powered Personalized Sustainability Insights:** Custom dashboard that examines the user's waste disposal habits can be incorporated into the system inorder to promote ecologically conscious behaviour. With the use of data driven insights into disposal practices, this feature will produce comprehensive reports on waste reduction initiatives performed by individuals and communities. This system will help recognize patterns and recommend areas for enhancements and offer customized sustainability advice depending on user behavior by utilizing machine learning algorithms.
- **Multi-language and Accessibility Support:** Future upgrades will have multiple language supports and improved accessibility features which ensures the app has a wide range of users. In order to implement seamless interaction between users with varying linguistic backgrounds the app will be updated to support numerous languages.
- **Integration with Government and Recycling Agencies:** Impact and uptake of BinHero app will be greatly increased by collaborating with regional governments, recycling organizations, environmental regulatory bodies. These collaborations can ensure adherence to regional sustainability regulations, enhance recycling infrastructure and enable a very smooth garbage collection. Furthermore, incorporating government rewards

for users who actively engage in appropriate trash disposal can be a potent inducement for sustainable behaviour.

10 CONCLUSION

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