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# AI AGAINST LITTER
## PROJECTPLAN

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# 1 CONTEXT AND RATIONALE

The project aims to detect litter using AI, thereby mapping and identifying areas with high litter density and identifying which type of waste is present: plastic, paper, green waste, or residual waste. To achieve this, we are creating a physical object, a user app, and a dashboard for companies and policymakers. We will deliver it as a working product that can practically be sent to a manufacturer for production.

## 1.1 DELIVERABLES
- **AI-model**: a working AI model that can distinguish between different types of trash.
- **Physical object**: a litter stick with a camera in it that can detect what kind of trash it is.
- **Dashboard/app**: overzicht van hotspots en trends.
- **Manual**: a manual so that future developers can continue with it.
- **Final presentation**: A final presentation in which we demonstrate to the client how it works and explain our process.

# 2 STAKEHOLDER ANALYSIS

**Primary Stakeholders**

- **Municipalities:** The main institutional beneficiaries. They need reliable data about litter to organize resources better and reduce cleaning costs.
- **Volunteers / Citizens:** People who already collect litter in streets and parks. Their problem is that they don't want to do paperwork or take photos to record the waste. They are key to testing the app and the physical litter picker.
- **Project team:** Us, the students, who are developing the app, the dashboard, the AI, and the physical prototype. Our interest is to successfully complete the project and make sure it works in real life.

**Secondary Stakeholders**

- **Environmental organizations :** They aim to raise awareness and can use our data for campaigns and education.
- **Professors / Avans University:** They supervise us, give feedback, and ensure the project meets academic standards.
  **Potential future partners (companies, businesses, policymakers):** They may later be interested in supporting, funding, or implementing the solution if it proves useful and scalable.

# 3 CHOICES & DECISIONS

**AI framework:**

- A full list of points will be provided in a new document called "YOLOv8-CNN.pdf" We choose to use YOLOv8 due to it being built for speed and easier to train than CNN, even though CNN would also be a good choice and is more mature.

**Hardware Platform:**

One of the most critical design choices in this project is the selection of the hardware platform that will support image capture for litter detection. The device must be mounted on the litter picker, integrate a camera, and transmit images to the AI pipeline for classification.

Since the solution is aimed at proving feasibility and accuracy rather than cost minimization, our main criteria are performance, reliability, and integration with the rest of the system.

The following factors were considered:

- **Image Quality**: Resolution, frame rate, and lens options.

- **Processing Power**: Ability to handle local AI inference or preprocessing.

- **Connectivity**: Support for Wi-Fi, Bluetooth, or wired transfer.

- **Size & Weight**: Must be practical to mount on the picker.

- **Ecosystem & Support**: Documentation, community, and available libraries.

- **Future Scalability**: Capacity to handle larger models or more complex tasks.

The analysis can be found in "BoardAnalysis.xlsx".

The final decision was made considering the evaluation criteria and the project goals:

- ESP32 boards are excellent for proof-of-concept but limited in image quality and processing.

- Jetson boards offer the best raw performance but are bulky and unnecessarily complex for a litter-picker prototype.

- Raspberry Pi 5 with a high-quality camera module strikes the right balance:

  o Sufficient processing power to run AI locally or act as a gateway.

  o Wide camera options (HQ Camera, IMX378, global shutter).

  o Strong community support and compatibility with existing libraries.

  o Scalable for future extensions (additional sensors, advanced inference).

The final choice was: Raspberry Pi 5 with Raspberry Pi HQ Camera (or equivalent IMX sensor).

This combination provides the best trade-off between performance, flexibility, and ecosystem support, ensuring the prototype is both robust for the client and extensible for future improvements.

# 4  PROBLEM ANALYSE

Litter in public spaces is still a big environmental, social, and economic problem. Municipalities organize regular cleanups, but these are often **not efficient**, because they are not based on clear data about where and when litter appears.

Volunteers also help by collecting waste in streets and parks, but there is another issue: **many of them do not like writing down the litter they collect or taking photos to classify it**. This process takes time, feels like paperwork, and makes volunteers less motivated. Because of this, the data collected is often incomplete or not reliable.

As a result:

- Municipalities do not have good information to plan their actions.
- Citizens lose motivation to take part.
- Cleaning becomes more expensive and less effective.

The real problem is not only "collecting more litter," but **making collection and data reporting simple and automatic** for volunteers, while giving useful information to the authorities.

# 5  INTENDED GOAL

The goal of this project is to create a practical and data-driven solution that helps reduce litter in public spaces and makes waste management more efficient. Our approach combines artificial intelligence, a physical prototype, and a mobile app to connect municipalities, volunteers, and citizens in one system.

More specifically, the intended goals are:

- Support municipalities and policy makers by providing accurate data about litter types, locations, and trends, so they can make better decisions and design effective waste policies.
- Engage citizens and volunteers by offering simple and user-friendly tools (a mobile app and a physical litter picker) that allow them to contribute without unnecessary paperwork or complex tasks.
- Automate data collection through AI models and digital tools, reducing the burden on volunteers who currently have to manually record and classify the waste they collect.
- Raise awareness about sustainability by showing the impact of litter through dashboards, maps, and statistics, making the problem visible and encouraging behavioral change.
- Create an iterative and scalable system that can be tested, improved with feedback, and potentially expanded to other cities or contexts.

In summary, the intended goal is not only to collect more litter, but to collect it smarter, while turning this activity into reliable data that supports cleaner cities, better policies, and more motivated communities.

# 6 TEAM ORGANIZATION

- **Cas**: Training the AI model.
- **João**: Developer of the hardware and the app.
- **Marcos**: Business planner.
- **Casper**: UI design of the dashboard and app, design physical object.

## 6.1 COMMUNICATION ARRANGEMENTS:

- **Whatsapp**: used for all mutual, and most communication.
- **Discord/Teams**: For all project documentation, such as minutes and work files.
- Weekly consultation with the project coach and teacher.

## 6.2 RULES

- Each member must dedicate time to the project, update weekly progress, and use the shared workspace.
- Respect the roles and work of others: do not change another member's work without discussion and always propose solutions instead of criticism.
- Major design or technical decisions are discussed collectively.
- Punctual attendance at meetings (physical or online).
- Ask for help if you are stuck with a task.
- Aim to complete all tasks with the best quality possible.
- Try to hold meetings in person whenever possible.
- Internal deadlines can be set.
- Maintain a positive and open attitude to create a good working environment.
- Celebrate every achievement and recognize each member's contribution.

# 7 QUALITY ASSURANCE

To ensure the success and reliability of the project, clear quality assurance measures are required. These measures will help guarantee that the final product is not only technically functional, but also user-friendly, maintainable, and aligned with stakeholder expectations. Quality assurance will be applied throughout the project lifecycle, from development to testing and delivery.

**Technical validation:**

- Train the AI with a labeled dataset; target accuracy ≥80% in classification.

- Conduct field tests with the litter stick to ensure robustness and usability.

**Usability testing:**

- Collect feedback from test users (citizens, policymakers).

- Refine UI/UX of dashboard and app based on early iterations.

**Documentation standards:**

- All codes are version-controlled and commented.

- A developer manual is delivered for future continuation.

**Criteria for success:**

- AI model consistently identifies waste with high accuracy.

- The prototype litter stick is fully functional for demonstration.

- Dashboard provides clear, actionable data visualization.

# 8  PLANNING

| ITERATION | WEEKS | FOCUS |
|---|---|---|
| 1 | 1 - 4 | Low-fi prototype litter stick<br>Train a minimal version of the litter detection AI, it will only detect plastic to start of with |
| FALL | 5 | |
| 2 | 6 - 8 | New prototype litter stick, begin 3D print versions of the litter stick<br>Improve the already trained AI model to detect different kinds of litter |
| 3 | 9 - 11 | Designing UI's<br>Further improve the AI detection |
| 4 | 12 - 13 | Finish design, def version litter stick<br>Further improve the AI detection |
| CHRISTMAS | 15 - 16 | |
| FINALIZING | 19 - 20 | Finalize the AI model |

# 9  RISK ANALYSIS

## 9.1. AI model accuracy

- **Risk:** The AI model may fail to correctly identify or classify litter types due to limited or unbalanced datasets.
- **How we can solve it:** Use larger and more diverse datasets (public datasets + own images); iterative training and testing; involve the AI team early to detect problems.

## 9.2. Usability of the physical tool

- **Risk:** The litter picker prototype may be too heavy, uncomfortable, or impractical for volunteers.

- **How we can solve it:** Test different materials (lightweight plastic, aluminum); involve users in early trials; collect feedback on ergonomics; create several iterations.

## 9.3. App complexity

- **Risk:** If the mobile app is not intuitive, citizens and volunteers may get frustrated and stop using it.
- **How we can solve it:** Design a simple interface with minimal steps; test prototypes with volunteers; prioritize user feedback over advanced features.

## 9.4. Missing deadlines

- **Risk:** Tasks may take longer than expected due to technical challenges or coordination issues.
- **How we can solve it:** Clear planning with realistic deadlines; weekly progress check-ins; redistribute workload if someone gets stuck.

## 9.5. Team engagement

- **Risk:** Some members may lose motivation if tasks feel too technical or disconnected from their role.
- **How we can solve it:** Rotate roles when possible; recognize contributions; ensure everyone understands their impact on the final outcome.