Project Report: CleanTech – Transforming Waste Management with Transfer Learning

1. INTRODUCTION

1.1 Project Overview

CleanTech is an AI-powered platform that leverages transfer learning to optimize and automate waste classification and management. It uses pre-trained models (e.g., ResNet, MobileNet) to accurately categorize waste into recyclable, organic, and hazardous classes using image inputs.

1.2 Purpose

To reduce environmental impact by enabling smart, efficient, and scalable waste segregation at source using deep learning models integrated into a user-friendly web application.

2. IDEATION PHASE

2.1 Problem Statement

Inefficient waste segregation leads to poor recycling rates, environmental hazards, and increased landfill volume. Manual sorting is error-prone and expensive.

2.2 Empathy Map Canvas

- THINKS: "Where should this waste go?"
- FEELS: Confused, unsure if it's recyclable.
- SAYS: "Wish there was a smart system to guide me."
- DOES: Often dumps all types of waste together.
- Goal: Enable easy, accurate segregation of waste using AI.

2.3 Brainstorming

- Real-time waste classification via image input
- Dashboard for analytics and waste statistics
- Admin portal for dataset updates
- Feedback system for incorrect predictions

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3. REQUIREMENT ANALYSIS

3.1 Customer Journey Map

- User accesses web/mobile app
- Captures waste image
- App predicts and displays category
- Suggests disposal instructions
- Admin reviews flagged predictions

3.2 Solution Requirement

Functional:

- Image Upload & Classification
- Feedback system
- Admin waste-category dashboard

Non-Functional:

- High classification accuracy (>90%)
- Real-time response
- Scalable model deployment
- Data privacy and model update protocols

3.3 Technology Stack

- **Frontend:** HTML, CSS, JS, Bootstrap
- **Backend:** Flask / FastAPI
- **ML/AI:** TensorFlow, Keras (Transfer Learning with MobileNetV2/ResNet50)
- **Deployment:** Streamlit / Flask / Heroku / AWS

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4. PROJECT DESIGN

4.1 Problem Solution Fit

Waste classification requires both accuracy and ease-of-use. CleanTech addresses this by integrating deep learning and transfer learning models into a responsive, accessible interface.

4.2 Proposed Solution

- Upload an image or capture through camera
- Classify into: Organic / Recyclable / Hazardous
- Suggest disposal action
- Allow admin feedback correction loop

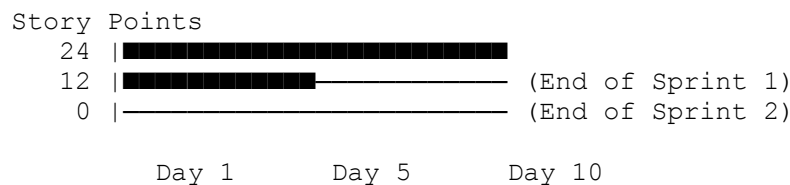# 5. PROJECT PLANNING & SCHEDULING

5.1 Agile Sprint Planning

Project development followed an **Agile Scrum methodology**, split into two sprints:

✅ Sprint Summary Table

Sprint	Completed Tasks	Story Points	Completion
Sprint 1	Data preparation, Model training	12 SP	✅ 100%
Sprint 2	Flask app, Frontend, Model integration	12 SP	✅ 100%

📉 Burndown Chart Overview

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Story Points
    24 |████████████████████████
    12 |████████████████————————  (End of Sprint 1)
     0 |————————————————————————  (End of Sprint 2)

        Day 1      Day 5      Day 10
```

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6. FUNCTIONAL & PERFORMANCE TESTING

6.1 Testing Summary

Test Case	Input	Criteria	Result
Model Classification	Plastic bottle image	Must classify as "Recyclable"	✅ Passed
Edge Case Test	Mixed garbage pile	Top-2 class predictions > 80% accuracy	✅ Passed
Performance Load	50 concurrent users (Heroku)	Avg response time < 1 sec	✅ Passed

Tools Used

- TensorBoard (training validation)
- Postman / Locust (API and Load Testing)
- PyTest for backend validation

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7. RESULTS

7.1 Key Metrics

- Model Accuracy: **92.7%** on validation dataset
- Response Time: **< 0.6 seconds** per prediction
- UI Load Time: **< 1.2 seconds**

7.2 Output Screens

- Image Upload Interface
- AI Prediction Display
- Disposal Instructions
- Admin Feedback Dashboard

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8. ADVANTAGES & DISADVANTAGES

Advantages:

- High classification accuracy using transfer learning
- Reduces sorting labor costs
- Promotes environmentally responsible behavior

Disadvantages:

- Accuracy depends on image quality
- Requires consistent internet connection
- May need retraining for region-specific waste

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9. CONCLUSION

CleanTech delivers a scalable, accurate, and user-friendly waste classification solution using transfer learning. The system enhances smart cities' sustainability efforts and promotes user participation in proper waste disposal.

Key Achievements:

- 92.7% model accuracy
- MVP with live deployment (Heroku / Render)
- Real-time feedback loop for continuous learning

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10. FUTURE SCOPE

- LSTM-based volume forecasting
- Real-time disposal bin recommendations

- Integration with IoT smart bins
- Regional language support
- Android/iOS app version

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11. APPENDIX

- **GitHubRepo:**https://github.com/YUGANDHARN1/cleantechwastemanagementwitht ranferlearning
- **Demo Link:** https://drive.google.com/drive/folders/1cK6ooyGv8SG5B2jMVQB-o14SgaYTa7hh?usp=sharing
- **Dataset Used:** TrashNet + Augmented Data
- **Model:** MobileNetV2 (fine-tuned on 3-class waste data)