Sandrix: A Solar-Powered Smart Beach Cleaning Rover

Project Report
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Platform: ESP32-CAM | GPS | Solar | Load Cell

□ Introduction

Plastic pollution is a rising environmental threat, particularly on coastal shores. Sri Lanka, home to some of the most biodiverse beaches, has been deeply affected by maritime disasters such as the X-Press Pearl ship fire. This project introduces **Sandrix**, a low-cost, solar-powered autonomous beach cleaning robot designed to collect microplastics (like PET pellets) from sandy environments using a mesh filter and smart navigation.

🎯 Objective

- Clean plastic pellets from beaches autonomously.
- Reduce manual labor in coastal cleanup efforts.
- Support national efforts like **"Clean Sri Lanka"**.
- Measure and monitor plastic load using sensors.
- Operate sustainably with solar charging.

⚙ Technical Specifications

Component	Description
Microcontroller	ESP32-CAM with OV2640 (Wi-Fi + Video)
Motors	4x 12V DC Geared Motors (100–300 RPM)
Motor Driver	L298N Dual H-Bridge
GPS	NEO-6M GPS module for autonomous pathing
Load Sensor	HX711 with 5kg Load Cell
Camera	Real-time video via ESP32-CAM
Scoop Mechanism	Front scoop with mesh underneath to retain plastic
Power Supply	2x 3.7V 18650 + TP4056 + 18V Solar Panel

Component	Description
Chassis	4WD rugged frame with wide wheels
Obstacle Detection	HC-SR04 Ultrasonic Sensor (optional)

🔋 Solar Integration

- A 18V solar panel mounted on top powers the system and charges batteries during daytime.
- Enables longer, cleaner missions without manual charging.
- Promotes green energy and eco-friendly tech.

⚖️ Load Measurement

- A plastic bin at the rear collects filtered plastic.
- Load cell under the bin continuously measures weight.
- Weight is displayed live on a web interface or OLED.
- Optional buzzer alerts when full.

🛰️ GPS Autonomous Navigation

- NEO-6M GPS used to define boundaries.
- Pre-mapped beach zones for auto cleaning.
- Zigzag pattern sweeping algorithm.
- Ultrasonic sensor avoids rocks or obstacles.
- Returns to base when full or battery low (future plan).

🌍 Background & Environmental Context

🎁 *Express Pearl Disaster (2021) – Sri Lanka*

- A major ship fire spilled **billions of plastic nurdles** across Sri Lanka's western coastline.
- Beaches from Colombo to Negombo were buried under microplastics.
- Marine life, including turtles and fish, died by ingesting plastic.
- UN declared it *"the worst marine ecological disaster in Sri Lanka's history."*

🐢 *Impact on Life*

- Marine creatures mistake nurdles for food → digestive blockages.
- Nurdles absorb heavy metals → toxins enter human food chain.
- Shoreline livelihoods and fisheries severely affected.

🏝️ Contribution to Clean Sri Lanka

- Sandrix complements manual efforts by NGOs and volunteers.
- Targets hard-to-detect microplastics in dry or wet sand.
- Inspires youth and students toward sustainable innovation.
- Reduces long-term environmental cleanup costs.

💰 Budget Estimate (Prototype)

Item	Cost (LKR)
ESP32-CAM	2,500
4x DC Motors	3,200
L298N Motor Driver	800
Chassis & Wheels	1,500
Load Cell + HX711	1,000
NEO-6M GPS Module	1,800
Solar Panel (18V 5W)	2,000
TP4056 Charging Module	300
Battery + Holder	1,000
Ultrasonic Sensor	400
Other Materials (Net, Scooper, Frame)	1,000

Total Estimate: ~~15,500 LKR (~~$50 USD)

🚀 Future Improvements

- AI-based plastic detection (Edge Impulse)
- Real-time dashboard (Firebase or Google Sheets)
- Night cleaning with infrared and LEDs

- Deployable swarms of Sandrix units

📚 References

- United Nations Environment Programme (UNEP)
- Reports on MV X-Press Pearl (2021)
- National Geographic: Marine Plastics
- Clean Sri Lanka Campaign
- Marine Conservation Institute