Use of Emerging Technologies to Solve Remote Indigenous Communities Challenges

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Introduction to Kampung Rantau Panjang, Kuching

📍 Township Overview:
- Located in Kuching, Sarawak, Malaysia.
- Situated near the banks of the Rajang River.
- Known for its scenic environment and cultural richness.

👥 Indigenous Community:
- Predominantly inhabited by the Bidayuh ethnic group.
- Longhouse living.
- Practices include festivals, traditional music (e.g., *Bergendang*)

📊 Population:
- Estimated population: around 1,000–1,200 villagers.
- Families live collectively in traditional longhouses.

🏠 Key Features:
- Longhouse is the centre of community life, ceremonies, and daily interactions.
- Rich indigenous knowledge in farming, herbal medicine, and traditional arts.

Problem Statement of Kampung Rantau Panjang

🚮 Core Problem:

- Improper waste disposal and littering throughout the village.
- Drainage systems frequently clogged by garbage, leading to **frequent flooding**.

📍 Background Context:

- Remote location and narrow, bumpy roads make waste collection difficult.
- Lack of recycling awareness and insufficient waste facilities.
- Flooding incidents supported by field surveys and local news reports.

⚠️ Why It Matters (Relevance):

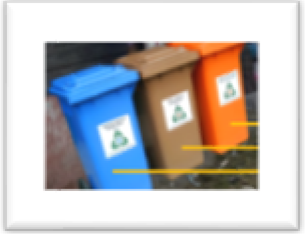
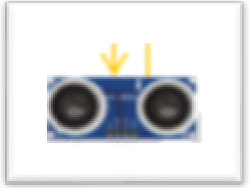
- Health risks: Diseases like dengue, leptospirosis, skin infections.
- Environmental hazards: Contaminated water, pest infestations, road damage.
- Safety threats: Wildlife (e.g., snakes, crocodiles) entering homes due to floods.
- Cultural impact: Damage to longhouses and disruption of indigenous lifestyle.

🎯 Objective:

- Develop a smart, solar-powered waste management system using IoT and AI.
- Improve hygiene, prevent flooding, and protect the community's cultural identity.

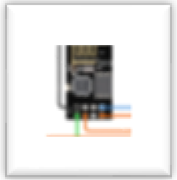
Design idea 1 : Diagram

Design idea 1: Approaches Used

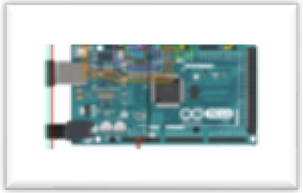
♻️ Reduce

- The smart waste bins help reduce waste overflow and illegal dumping by alerting the authorities when bins are full.
- The design also encourages community participation in responsible disposal and recycling, reducing environmental pollution.



🚫 Prevent

- By monitoring drain water levels and blockage in real time, the system prevents flooding before it escalates.
- Regular waste collection triggered by IoT alerts helps prevent waste accumulation that leads to clogged drains.



🔍 Predict

- The AI dashboard and IoT sensors analyze patterns thru the Arduino to predict potential flooding risks and areas likely to be affected.
- Predictive data allows early response planning, reducing the impact of waste-related disasters on the community.

Design idea 1: Design Benefit

🌐 1. Access and Equity

• Ensures that all villagers have equal access to efficient and modern waste management.
• Real-time monitoring prevents waste overflowing from the bin, ensuring prompt garbage collection and drainage maintenance regardless of location.

🛡️ 2. Health and Safety

• Reduces health risks by preventing blocked drains and waste overflow, which can cause flooding and the spread of waterborne diseases such as dengue and leptospirosis.
• Promotes a cleaner and more sanitary environment, especially beneficial for children, elderly, and those with weaker immune systems.

🌱 3. Sustainable Livelihoods

• Empowers local community members by involving them in the system's maintenance and data monitoring roles.
• Builds technical capacity and eco-awareness through hands-on experience with emerging technologies (IoT, AI, solar).

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Design idea 1: Design Benefit

🏞️ 1. Tourism
- Clean environment enhances village aesthetics, preserving cultural attractions like longhouses and traditional dances.
- Attracts eco-tourists and cultural visitors, supporting sustainable tourism.

🌿 2. Medicinal Use of Plants
- Reduces pollution, allowing medicinal plants (e.g., *tengkawang*, *akar kayu*, *limau purut*) to thrive.
- Protects traditional remedies and ensures intergenerational knowledge sharing.

💰 3. Income Generation
- Prevents flood damage to farms and traditional craft areas, supporting stable income.
- Enables new income streams through recycling, composting, and eco-based industries.

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Design idea 1: Design Constrains

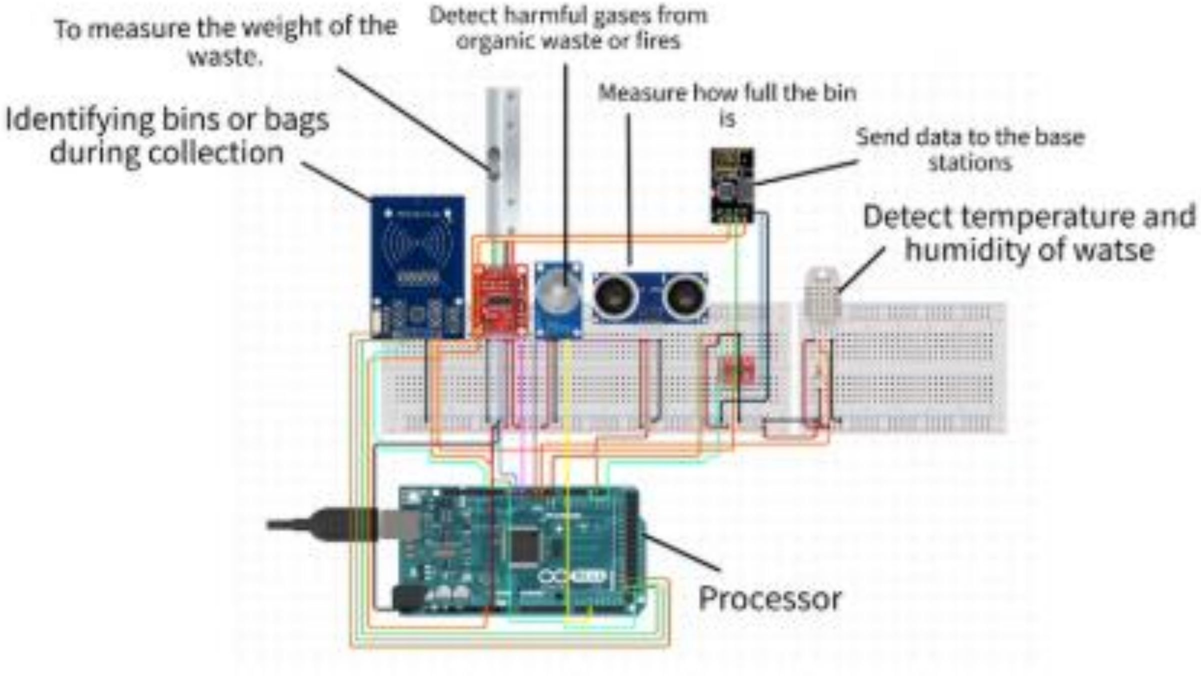
📶 1. Limited Network Connectivity

- Remote areas may lack stable LoRaWAN or GSM coverage, disrupting real-time data transmission from smart bins and drain sensors.

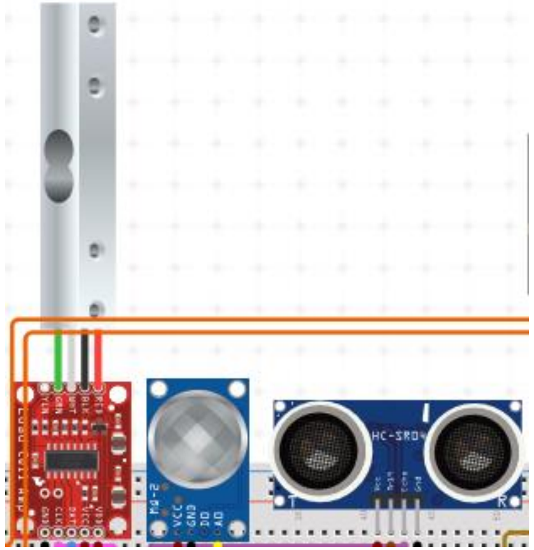
💸 2. High Initial Cost

- Installation of IoT sensors, processors, solar panels, and infrastructure involves significant upfront costs.
- May require external funding or government support to implement fully.

Design idea 2



Design idea 2 : Design Approaches



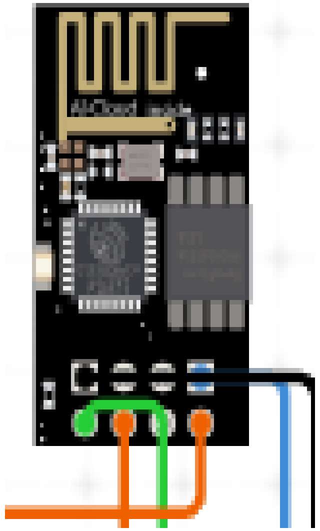
Reduce

Environment pollution

Operational costs and optimise collection routes

Prevent

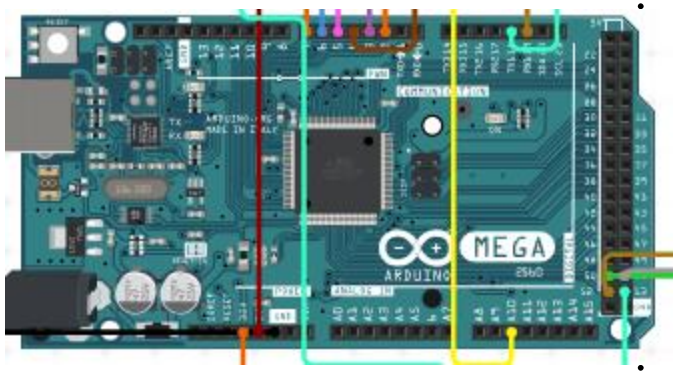
Growth of disease such as dengue, malaria and more



Prevent

Waste overflow through real-time monitor

Residual harmful substances and gases



Predict

Time for collection when a bin is full

Monitor the fill level and predict the data so earlier action could take

Design idea 2 : Design Benefits

- **Access & Equity**: The wireless system ensures all areas even those with poor road accessibility are included in waste monitoring and collection, promoting fairness in public services.
- **Health & Safety**: Sensors detect harmful gases, fires and overflowing bins early for preventing disease and fire outbreaks.
- **Appropriateness**: The technology is low-cost, easy and simple to maintain, and suits the local context, making it highly practical.
- **Environmental Health**: The system reduces illegal dumping and waste overflow, which protects waterways, soil, and air quality.

- Explain your design benefits, impacts and constraints clearly

Design idea 2: Design Impact

Improve well-being

Green and healthy environment

Villagers take part in monitoring environment

Prevent growth of bacteria and virus

Design Idea 2: Design Constraints

1. Limited Network Connectivity: Some parts of the village may not have stable signal coverage, which could affect real-time data transmission.

2. High Initial Cost: Procuring sensors, processors, and installation may be costly and require external funding or government support.

3.Data security concerns: Data transmitted and stored by smart bins can be vulnerable to cyberattacks and breaches, requiring robust security measures.

4.Technological Dependence and Reliability: Smart bins rely heavily on the functioning of sensors and 5G connectivity. Any failure in these components can disrupt the entire waste management process.

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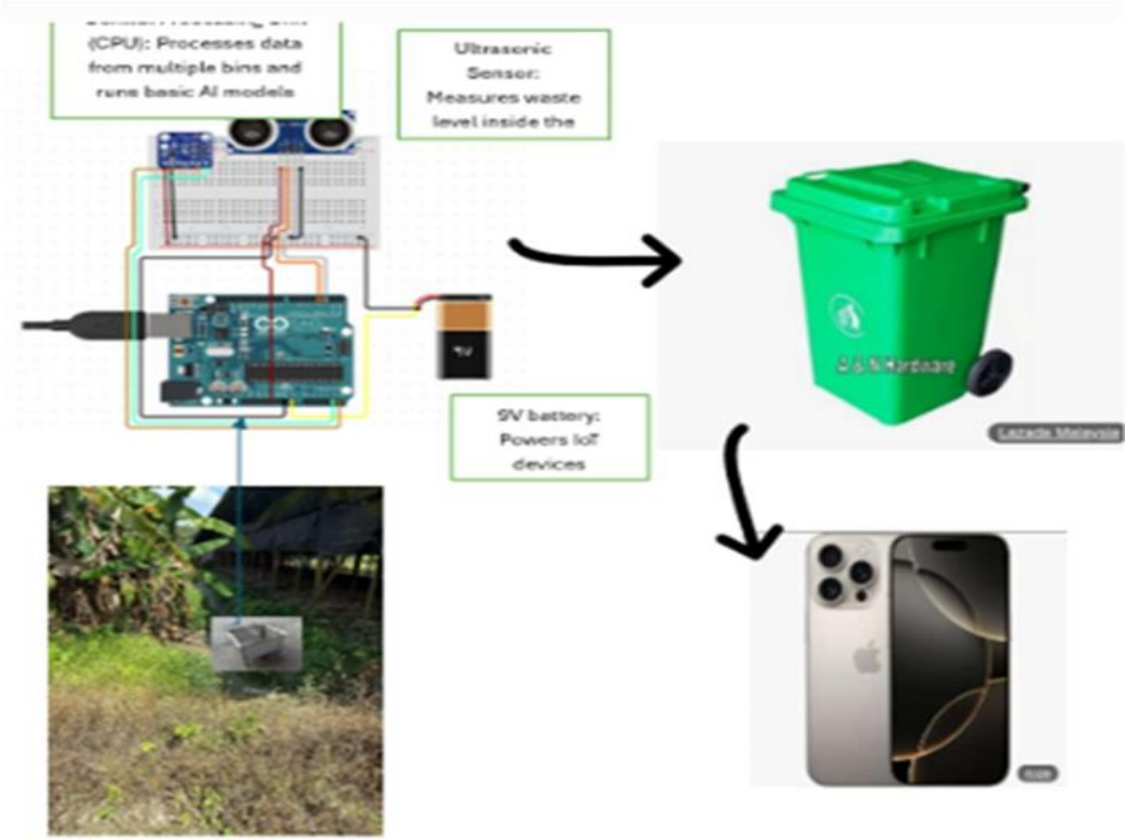
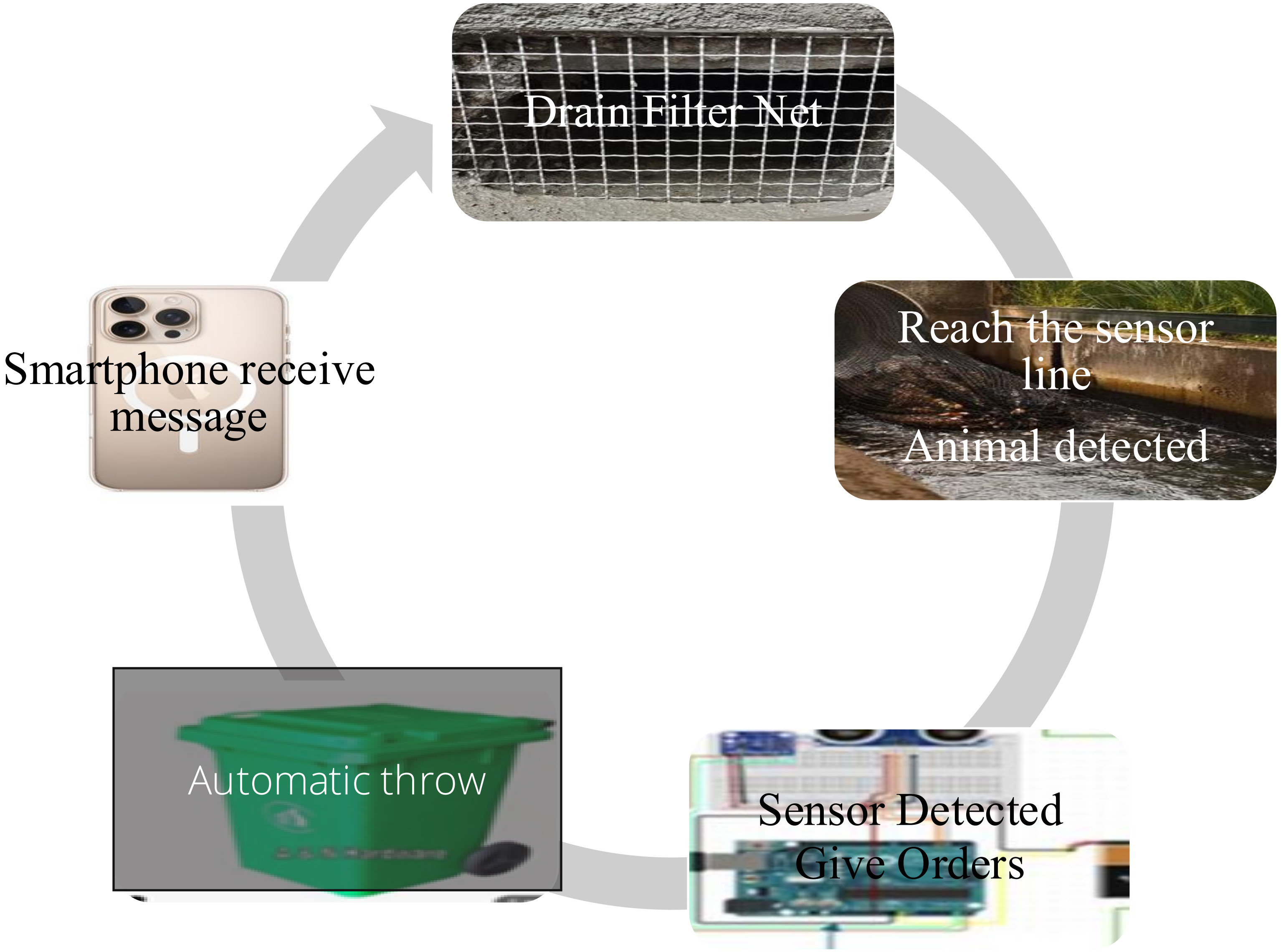
Design Idea 3



AI + Smart Sensors + IoT

Design Idea 3 (Function Introduction)



Design Idea 3:AI + Smart Sensors + IoT

Smart Sensors

What They Do:

- 📏 Detect bin fill levels (ultrasonic/weight sensors)
- 🌡️ Measure temperature (alerts for fire risks)
- 🧪 Identify waste types (chemical or image-based sensors)

Software Used

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Design Idea 3:AI + Smart Sensors + IoT

IoT (Internet of Things)

How It Works:

•Sensors send data in real time to a central system

Key Features:

- 📍 Live tracking of bin status across the city
- 🚨 Alerts when bins are full or need maintenance

Sample Visual:

•City map with connected bins, trucks, and a central dashboard

Software Used

Design Idea 3:AI + Smart Sensors + IoT

AI (Artificial Intelligence)

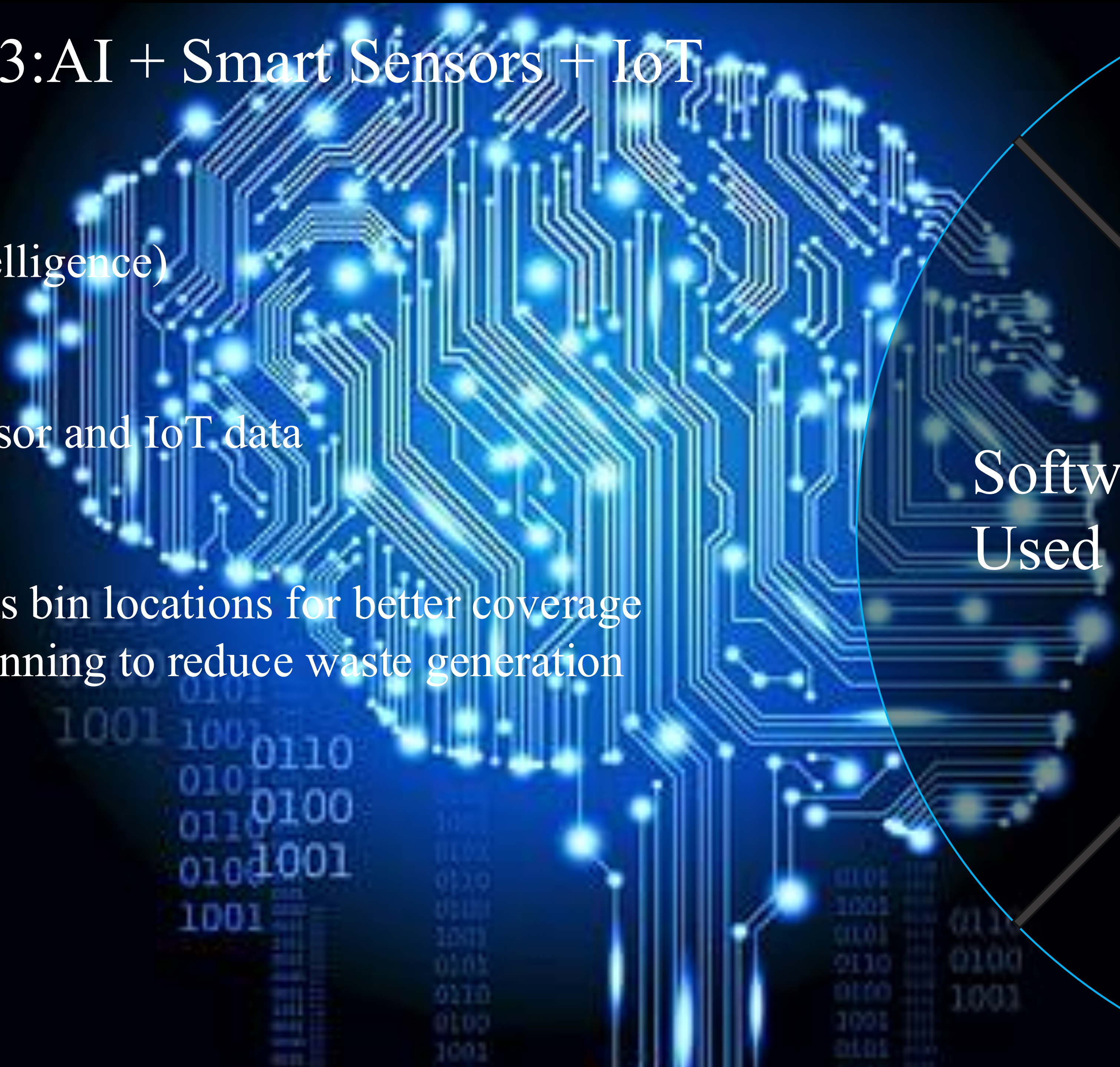
How AI Helps:

•Analyzes all sensor and IoT data

What It Does:

- 📍 Recommends bin locations for better coverage
- 🏙️ Supports planning to reduce waste generation

Software Used



Design Idea 3:AI + Smart Sensors + IoT

- Uses real-time data sharing and dynamic route planning to reduce environmental impact.
- Smart drainage nets prevent pollution, reflecting harmony with nature.
- Supports cultural preservation while promoting a cleaner, sustainable future.

Benefit of the Idea

Design Idea 3: AI + Smart Sensors + IoT

- Smart drainage technology prevents pollution in line with traditional practices.
- Blends modern innovation with traditional ecological knowledge.
- Helps preserve cultural heritage while advancing sustainability.

Culturally Appropriate

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Design Idea 3:AI + Smart Sensors + IoT

- Enhances public health by preventing bin overflows and detecting hazards.
- Supports cleaner streets and healthier communities.
- Creates more liveable, efficient, and environmentally friendly urban spaces

Design Benefit

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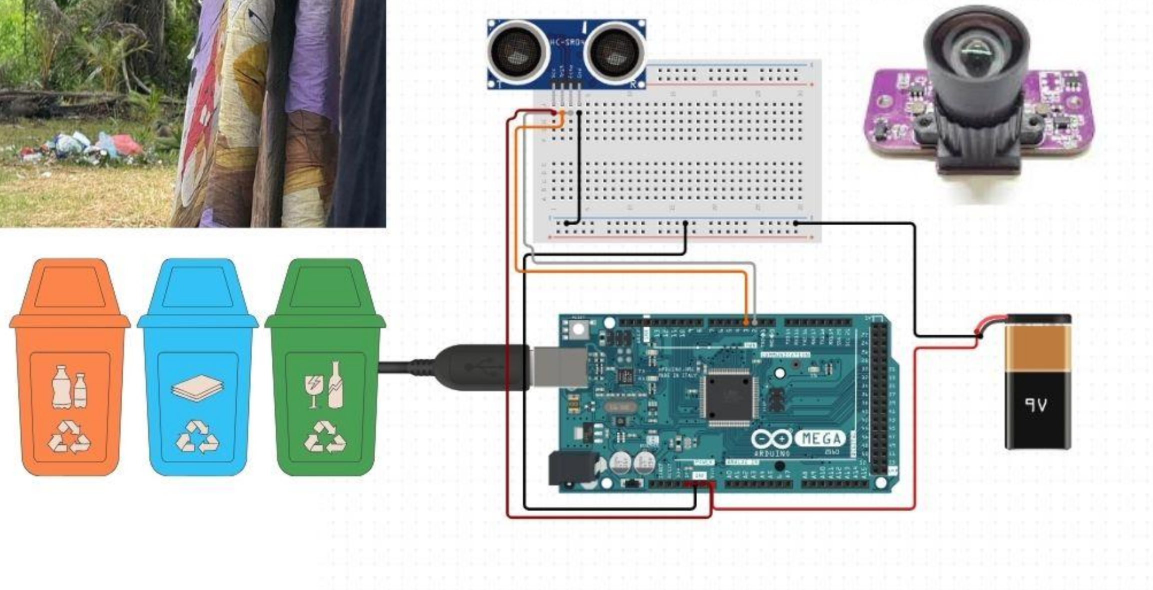
Design idea 4: Smart Bin + Mobile App + Gamification System

Ultrasonic Sensor (HC-SR04: To measures the waste level in bin

Near-Infrared (NIR) Sensors: determine its material composition.



Mobile App:

- Syncs with smart bin to track recycling stats and waste level
- Garbage collector feedback

Gamification:

- Users earn points based on proper sorting and garbage collector's feedback
- Points = reward
- Leaderboards

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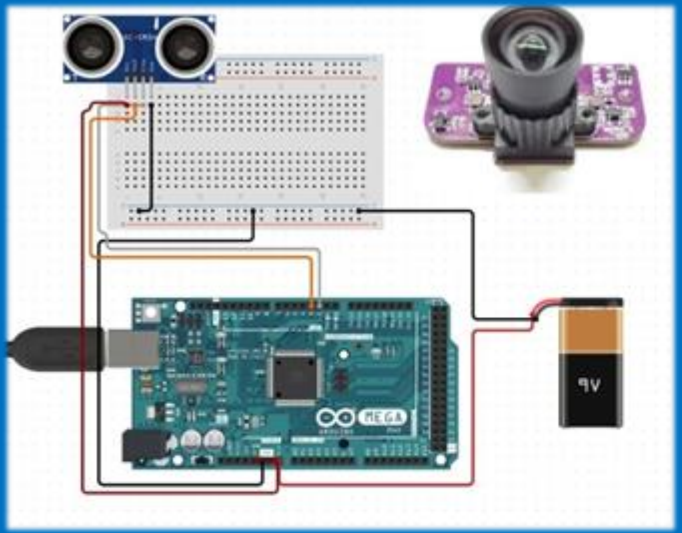
1

Analyse

- Ultrasonic sensor
- NIR sensor

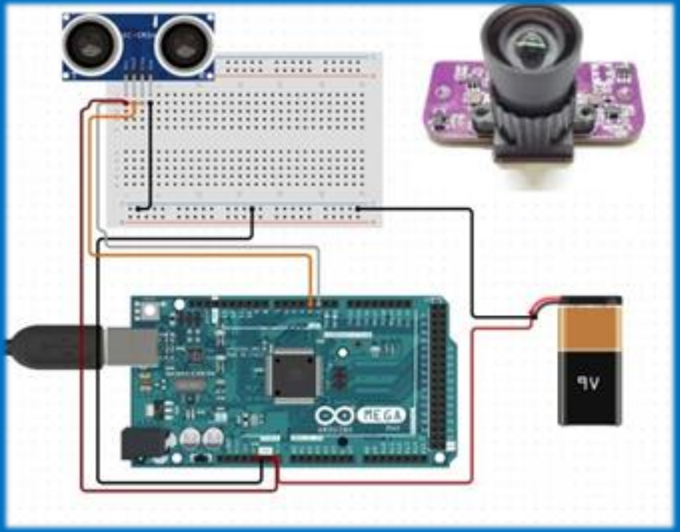


What are the different approaches used in this design?

1

Analyse

- Ultrasonic sensor
- NIR sensor



2

Reduce

- Encourage users to do waste prevention and segregation
- Mobile App
- Gamification system

3

Prevent

- Prevent flooding caused by littering
- Garbage collector feedback

Design idea 4: Benefits

1. Environmental health

- minimizes plastic and organic waste clogging drains

2. Health & Safety

- Reduce pests breeding

3. Affordability

-Ultrasonic sensor

- NIR sensor

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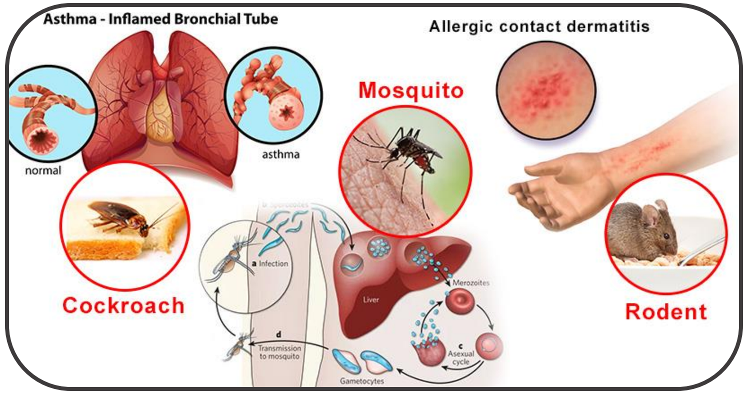
Design idea 4: Impacts

Prevent flooding



Prevent diseases cause by pests

Make waste prevention and proper waste segregation a norm

Design idea 4: Constraints

Users might find this inconvenience

Too rely on users cooperation

Rural areas may lack stable network connection for real-time data sync.

Design Justification

Approaches	Design 4 (BEST)	Design 5 (BEST)	Design 1 (LEAST)	Design 2 (LEAST)
Analyse				
Reduce	The system reduces waste overflow and environmental pollution by monitoring bin levels and promoting timely collection.	The smart bin can reduce environment pollution and prevent the growth of disease by managing the waste level real-time to prevent overflow and harmful and toxic rubbish in the bin	The system can reduce environment pollution due to the disease growth and prevent the animals likes rats and mosquitoes.	The system can reduce environment pollution due to littering and growth of mosquitoes which can spread diseases.
Eradicate				
Prevent	It prevents drain blockages and flash floods by detecting early signs of water buildup and sending alerts to the authorities.	It prevents the growth and spread of bacteria and viral infections such as aedes, malaria, dengue fever and more.	The system can prevents spread of bacteria likes aedes, malaria and block the drain.	The system prevents the spread of diseases due to mosquitoes and drain blockages which may cause flooding.
Predict	Through real-time data and trend analysis, the AI dashboard predicts potential flooding or waste issues, enabling proactive decision-making.	With real-time systems, ultrasonic and temperature sensors in bins, AI dashboard predicts hazard and waste issues and empowers detectors to make proactive decisions	The system can also prevent the rubbish overflow.	This system can prevent waste overflow by ensuring timely collection through smart notifications and encouraging proper sorting with gamified user engagement.
Design guidelines				
Access and Equity	7.4 (The village have electricity)	6.6 (The village is accessible to electric and water supply)	6.8 (The viliage has water and electricity).	6.6 (The village has water and electric supply)
Health and Safety	6.6 (touchless system enable users to preventing any risk)	5 (The smart bin is fullfil the health and safety standard)	5.2(The rubbish bin is satefy to prevent the animal)	5.4 (The system uses environmentally friendly materials and practices.
Appropriateness	4 (the waste collection department can monitoring the waste level by real time to make sure the rubbish will not overflowing form the bin)	3.8 (The smart bin can monitore the waste level in the bin according to real time, and ensure the waste is not overflowing and cause growth of bacteria.)	4.4(the rubbish bin use sensor to prevent the drain block)	4.4 (The smart bin use sensor to detect the level of waste to prevent the rubbish from overflowing)
Environmental Health	1 (the components can be used for 15 years and above)	5.6 (The components can be used for 15 years and above)	2.8(The rubbish can clean the surrounding rubbish)	2.4 (The system will not cause environmental pollution)
Sustainable Livelihoods	7 (the smart waste management is already implement in Singapore for a period of time)	6.4 (The smart bin system focus on reuse and recyclability while it was almost finish their cycle and it is already implement in Singapore for a period of time)	6.2(The smart system can be reuse).	6 (The components can last for 15 years and above)
Cultural appropriateness	https://www.canva.com/design/DAGnC7F4w6w/tMOwEAu6K201OO4_UABrvg/edit?utm_content=DAGnC7F4w6w&utm_campaign=designshare&utm_medium=link2&utm_source=sharebutton	https://www.canva.com/design/DAGnC7F4w6w/tMOwEAu6K201OO4_UABrvg/edit?utm_content=DAGnC7F4w6w&utm_campaign=designshare&utm_medium=link2&utm_source=sharebutton	https://www.canva.com/design/DAGnC7F4w6w/tMOwEAu6K201OO4_UABrvg/edit?utm_content=DAGnC7F4w6w&utm_campaign=designshare&utm_medium=link2&utm_source=sharebutton	https://www.canva.com/design/DAGnC7F4w6w/tMOwEAu6K201OO4_UABrvg/edit?utm_content=DAGnC7F4w6w&utm_campaign=designshare&utm_medium=link2&utm_source=sharebutton

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Thank you