Energy, Waste and Data – The Future

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Some Examples of Digitization

1. Existing tools such ERP for waste collection and handling
2. Simulations of waste streams and solutions.
3. The Use of Applications (APPs) on mobile devices
4. The use of wider extended producer responsibility schemes
5. The use of Artificial Intelligence – materials identification to advances in AIs for all of the above

Today, we will share some examples of items 2 through 5.

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Solutions for Waste

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Activities that change the volume and composition of waste generated

Prudent order of Waste Management based on Waste Management Hierarchy
Prevention being the highest and most preferred (ADB Energy Policy 2020)

Source → Prevention (Tier 1) → Prepare for reuse (Tier 2) → Recycling (Tier 3) → Recovery (Tier 4) → Disposal (Tier 5)

Example Municipal Waste generation:

See Screening example on following slides

5 planning scenarios used to demonstrate complexity

Examples of individual Activities (not full list)

Prevention (Tier 1):
- Waste reduction policies
- EPR policy
- Digital tools (APPs) for improved waste tracking, sorting, and recycling

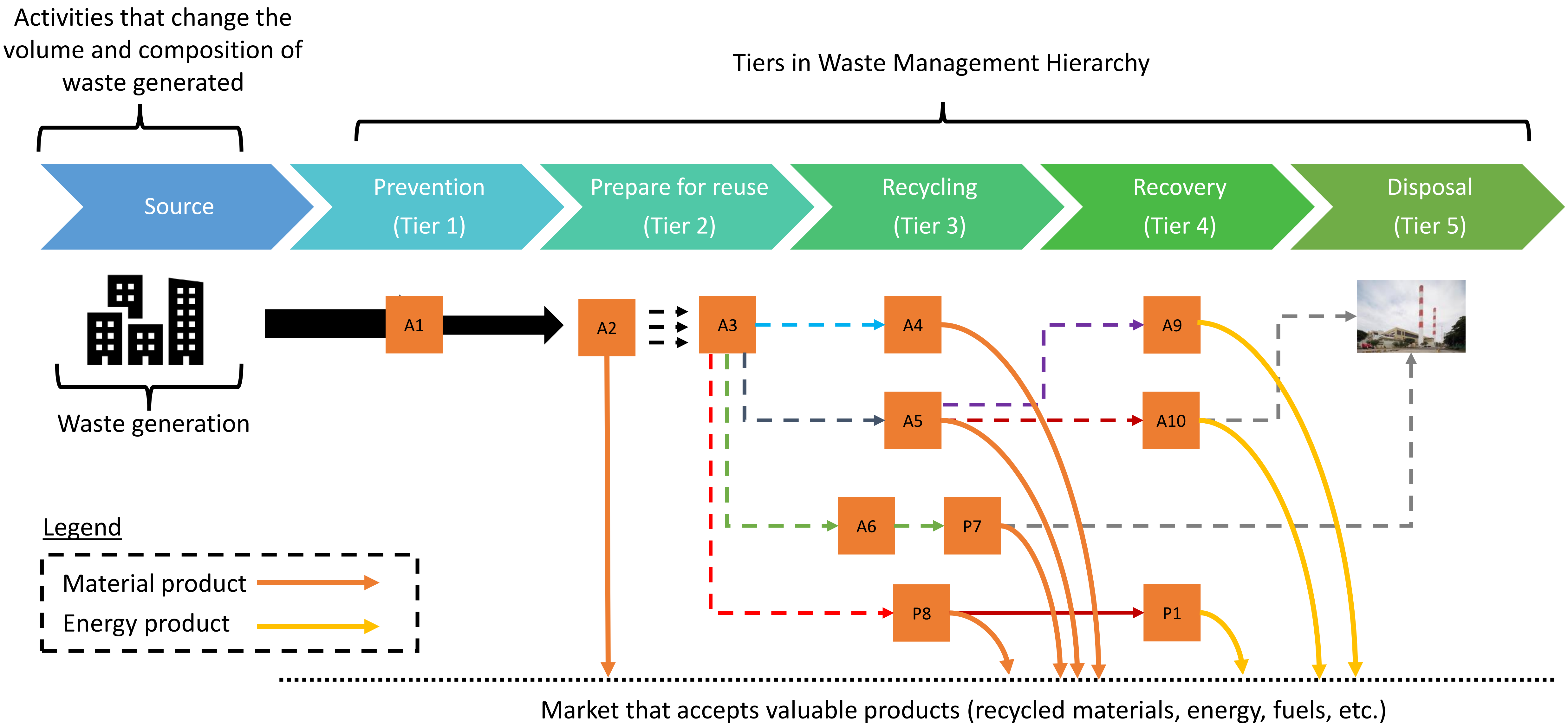
Prepare for reuse (Tier 2):
- Large material recovery facility (MRF)
- Eco-industrial park MRF
- Small MRF
- Informal waste pickers
- Secondary sorting
- Compost

Recycling (Tier 3):
- PE/PET/PP recycling
- Torrefaction
- Black soldier fly farms
- Paper & Metals recycling (aluminum, copper, etc.)

Recovery (Tier 4):
- Gasification
- Pyrolysis
- Waste to fuels
- Energy from Waste (EfW)
- Anaerobic digestion
- Refuse derived fuel (RDF) or (SRF)
- Landfill gas to power/energy

Disposal (Tier 5):
- Open dump closure
- Landfill
- Wastewater treatment
- Incinerator
- Landfill Mining

Object Based Modelling - Agents



Model Parameters and Results

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Model uses waste composition data and agent process data to explore and measure the environmental and economic performance of different waste management scenarios.

Model Parameters

Waste Composition

Waste	Quality	Composition (%)	Mass (tonnes/day)
Food and kitchen waste	Dry recyclable	20%	40
	Commingled	40%	80
	Wet	40%	80
Other Organic	Dry recyclable	20%	18
	Commingled	40%	36
	Wet	40%	36
Paper & Cardboard	Dry recyclable	20%	12
	Commingled	40%	24
	Wet	40%	24
Plastics	Dry recyclable	20%	26
	Commingled	40%	52
	Wet	40%	52
Leather and Rubber	Dry recyclable	20%	8
	Commingled	40%	16
	Wet	40%	16
Textile	Dry recyclable	20%	8
	Commingled	40%	16
	Wet	40%	16
Metal	Dry recyclable	20%	8
	Commingled	40%	16
	Wet	40%	16
Glass	Dry recyclable	20%	12
	Commingled	40%	24
	Wet	40%	24
Ceramic & Stone	Dry recyclable	20%	22
	Commingled	40%	44
	Wet	40%	44
Special/Hazardous	Dry recyclable	20%	6
	Commingled	40%	12
	Wet	40%	12
Other/residual	N/A		200
Freewater			500
Total			**1500**

Agent Process Data (inputs and outputs)

Category	Input/output flow	Unit	Amount
Waste input	Waste stream	tonnes	-
Ancillary inputs	Labor	person-hours	-
	Land area	hectares	-
	Electricity	kWh	-
	Water	M3	-
Valuable outputs	Energy	MWh	-
	Products	tonne	-
Specialty items	Biodiesel, biochar, fertilizer, etc.	tonne	-
Less valuable outputs	Digestate	tonnes	-
	Process Water	M3	-
	Outputs to legacy	tonne	-
	Waste (to EfW plant)	tonne	-
Environment	CO2	kg	-
	uPOPs	g	-
	Particulate matter (PM)	g	-
	Sox	g	-
	Nox	g	

Model Results

Economic and Financial Indicators

- Net present value
- Annual shortfall
- Capital costs
- Operating costs

Environmental Indicators

- Greenhouse gases (CO_2-eq)
- Nitrogen oxides (NO_x)
- Sulfur oxides (SO_X)
- Particulate matter (PM)
- Unintentional Persistent Organic Pollutants (UPOPs)

Social Indicators

- Disability adjusted life years
- Jobs - male/female
- Jobs - formal/informal
- Access to waste services

How the WARPS Tool Works

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A Tool for Planning Waste Management Systems and Analyzing the Environmental, Economic, and Social Performance

Introduction and Background

Enabling a circular economy requires strategic planning of waste management systems. Such systems should provide environmental, economic, and social benefits, but can be very complex due to the various types of waste streams and options for managing waste at different stages. The Asian Development Bank has developed this excel-based tool to compare potential waste management systems and measure their environment, economic, and social performance. The tool provides users with a means of taking a first-cut look at a variety of what-if scenarios for managing waste at different scales.

Purpose of Tool

ASSIST
policy makers plan out pathways for managing different types of wastes.

EXPLORE
the effects of prices and policies on waste management systems.

QUANTIFY
environmental, economic, financial, and social performance to inform what aspects a future full feasibility study could focus on.

Tool Structure and User Guide

Step 1: Create waste profile	
Step 2: Select agents to design system	
Step 3: Set policy and price conditions	
Step 4: View results	
Step 5: Visualize system in Sankey diagram	

For each scenario to be analyzed, the user must download a separate spreadsheet to model and analyze the waste management system designed.

Color Coding

(light blue)	Values that users can vary.
(blue)	Values that should be kept fixed.

Basic Waste Parameters

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User interface steps

1. **Enter waste profile**
2. Select waste management agents
3. Set policy and price conditions
4. View results in the dashboard

Waste Generation Profile

Scenario Name
Baseline scenario

Total MSW waste (tonnes/day)	355

Total industrial waste (tonnes/day)	-

Name of municipal solid waste stream	Percent	Volume of waste (tonnes/day)
Food and kitchen waste	0.0%	-
Other organic	46.0%	163
Paper and cardboard	15.0%	53
Plastics	21.0%	75
Leather and rubber	0.0%	-
Textile	0.0%	-
Metal	6.0%	21
Glass	4.0%	14
Ceramic and stone	0.0%	-
Special / hazardous	0.0%	-
Other	8.0%	28

Name of industrial waste stream	Percent	Volume of waste (tonnes/day)
Rice husk	0.0%	-
Sorted PE	0.0%	-
Sorted PET	0.0%	-
Sorted PP	0.0%	-
Waste biomass	0.0%	-
Medical waste	0.0%	-
Sorted paper	0.0%	-
Sorted cardboard	0.0%	-
Sorted newsprint	0.0%	-

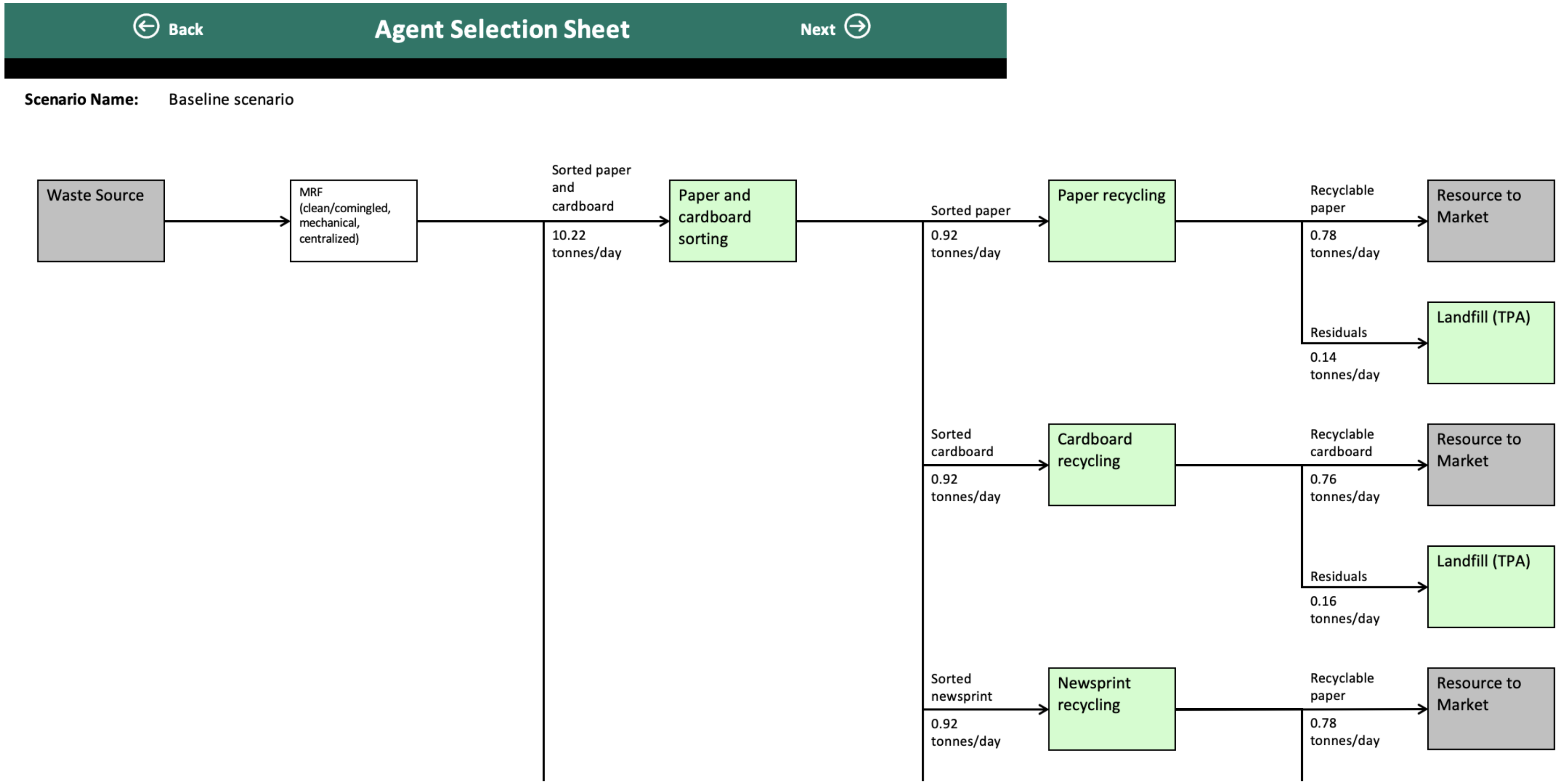
Confirm Waste Profile

Back Next

Setting up Waste Flows

User interface steps

1. Enter waste profile
2. **Select waste management agents**
3. Set policy and price conditions
4. View results in the dashboard



Adding Policy Information

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User interface steps

1. Enter waste profile
2. Select waste management agents
3. **Set policy and price conditions**
4. View results in the dashboard

Back | **Prices and Policies** | Next

Waste reduction policy

Estimated policy costs

Initial policy investment (USD)	
Annual policy cost (USD/year)	

Examples of waste reduction policies

Policy	Extended producer responsibility	Education campaign	Product redesign to minimize waste	Digital tool to reduce waste generation
Initial policy investment (USD)	$ -	$ -	$ -	$ 10,000
Annual policy cost (USD/year)	$ 150,000	$ 100,000	$ 500,000	$ 2,000

In this section, the user can consider implementation of waste reduction policies. To represent a policy or collection of policies, simply enter:
(1) the total estimated cost of the start of the policy
(2) the annual cost of maintaining, if any
(3) the estimated percent reduction in waste generation for each type expected to be achieved by the policy

If there is no waste reduction policy, set all values in the blue cells to zero (0).

Estimated waste reduction achieved through policy implementation

Waste stream	Waste reduced through policy	Waste volume before policy (tpd)	Waste volume after policy (tpd)
Food and kitchen waste	0%	0	0
Other organic	0%	163	163
Paper and cardboard	0%	53	53
Plastics	0%	75	75
Leather and rubber	0%	0	0
Textile	0%	0	0
Metal	0%	21	21
Glass	0%	14	14
Ceramic and stone	0%	0	0
Special / Hazardous	0%	0	0
Other	0%	28	28

Inputting Context Specific Economic Data

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User interface steps

1. Enter waste profile
2. Select waste management agents
3. **Set policy and price conditions**
4. View results in the dashboard

Back | **Prices and Policies** | Next

Facility-level prices and operating assumptions

This section is for setting the prices and operation conditions that are applicable across all facilities in a waste management system.

Facility operation assumptions

Working days per week	6
Weeks per year	52
Working hours per day	10

Eco-industrial park factors*

Recyclables price factor	1

*1 refers to the existing price. A factor of 1.2 refers to a 20% increase in price of resources that can be sold

General facility costs

Category	Item	Unit	Value
Waste	Waste collection fee (tipping/gate fee)	USD/tonne	$ -
	Waste disposal fee (landfill/incinerator)	USD/tonne	$ -
Ancillary	Water price	USD/m3	$ 1.50
	Electricity	USD/kWh	$ 0.10
	Diesel	USD/liter	$ 0.74
Land rental	Land rental	USD/sqm-month	$ 3.49
	Initial land purchase	USD	
Labor	Supervisor	USD/person-day	$ 13.97
	Middle	USD/person-day	$ 8.73
	Helper	USD/person-day	$ 7.68

Adding Market Pricing Information

User interface steps

1. Enter waste profile
2. Select waste management agents
3. **Set policy and price conditions**
4. View results in the dashboard

Back **Prices and Policies** Next

Sale value of resources to market

Users can use this sheet to set the estimated monetary value of what a resource (material and/or energy) can be sold at.

Category	Item	Unit	Value
Physical goods	Sorted food and kitchen waste	USD/tonne	$ -
	Sorted other organic	USD/tonne	$ -
	Sorted paper & cardboard	USD/tonne	$ 69.93
	Sorted mixed plastics	USD/tonne	$ 83.92
	Sorted leather and rubber	USD/tonne	$ -
	Sorted textile	USD/tonne	$ -
	Sorted metal	USD/tonne	$ 48.95
	Sorted mixed glass	USD/tonne	$ 34.97
	Sorted ceramic & stone	USD/tonne	$ -
	Sorted special/hazardous	USD/tonne	$ -
	Mixed RDF from MRF	USD/tonne	$ -
	Sorted organics	USD/tonne	$ -
	Polystyrene (PS)	USD/tonne	$ -
	Polyvinyl chloride (PVC)	USD/tonne	$ -
	Acrylonitrile butadiene styrene (ABS)	USD/tonne	$ -
	PET pellets	USD/tonne	$ -
	PP pellets	USD/tonne	$ -
	PE pellets	USD/tonne	$ -
	Black soldier fly larvae protein	USD/tonne	$ -

Simulation Summary

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User interface steps

1. Enter waste profile
2. Select waste management agents
3. Set policy and price conditions
4. **View results in the dashboard**

Summary Report

Summary of Financial, Economic, Environment, and Social Performance of Waste Management System

Financial		
Total capital invesment (USD)	$	210,000,000
Net present value before tax (USD)	$	(183,212,883)

Economic		
Government tax revenue (USD/year)	$	756,707
Total new jobs		500

Environment	
GHG emissions (tonnes CO2-eq)/year)	17,622
NOx emissons (kg/year)	16,901
SOx (kg/year)	12
Particulate matter (kg/year)	59.11755633
uPOPs (kg/year)	0.000

Social	
Access to waste collection services (persons)	681,637
Jobs for women	200
Jobs in formal sector	200
Jobs in informal sector	300
Disability adjusted life years	3.4

Agent Specific Results and Aggregation

User interface steps

1. Enter waste profile
2. Select waste management agents
3. Set policy and price conditions
4. **View results in the dashboard**

Financial performance results summary

Agent name	Unit	Entire system (All agents)	MRF (dirty, mechanical, centralized)	Anaerobic digester	Landfill (non-hazardous waste, sanitary with leachate and gas management)	Resource to Market
Number of facilities		3	1	1	1	
Input amount to agent	Tonnes/day		555.00	234.94	176.42	123.10
Capacity per facility	Tonnes/day		555.00	250.00	555.00	1.00
Maximum capacity	Tonnes/day		555.00	250.00	555.00	
Financial performance						
CAPEX	USD	(14,794,406)	(4,500,000)	(4,700,000)	(5,594,406)	
Land	USD/year	(174,500)	(34,900)	(139,600)	0	
Labor	USD/year	(1,359,755)	(738,473)	(498,857)	(122,426)	
Electricity	USD/year	(48,485)	(48,485)	0	0	
Water	USD/year	0	0	0	0	
Petrol	USD/year	0	0	0	0	
Diesel	USD/year	0	0	0	0	
Other	USD/year	(2,208,060)	(109,900)	(2,050,478)	(47,682)	
Total OPEX	USD/year	(3,790,800)	(931,758)	(2,688,935)	(170,108)	
Revenue	USD/year	4,595,169	3,042,191	1,552,978	0	
Profit/loss before tax	USD/year	804,369	2,110,434	(1,135,957)	(170,108)	
Tax	USD/year	(422,087)	(422,087)	0	0	
Profit/loss after tax	USD/year	382,282	1,688,347	(1,135,957)	(170,108)	
NPV before tax	USD	(8,020,216)	13,273,532	(14,266,739)	(7,027,009)	
NPV after tax	USD	(11,574,922)	9,718,826	(14,266,739)	(7,027,009)	

More Agent Specific and Aggregation Results

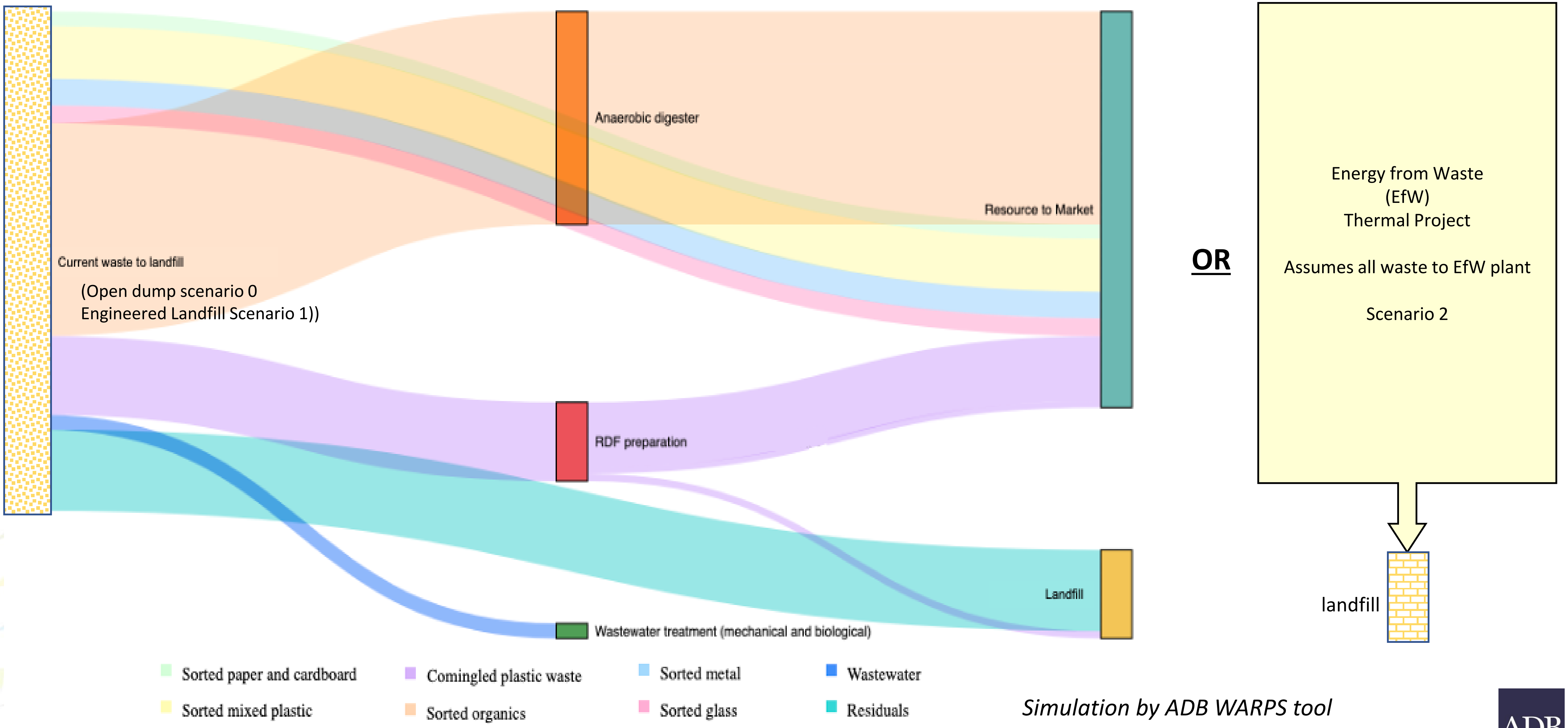
User interface steps

1. Enter waste profile
2. Select waste management agents
3. Set policy and price conditions
4. **View results in the dashboard**

Environmental performance results summary

Agent name	Unit	Entire system (All agents)	MRF (dirty, mechanical, centralized)	Anaerobic digester	Landfill (non-hazardous waste, sanitary with leachate and gas management)	Resource to Market
Number of facilities		3	1	1	1	
Input amount to agent	Tonnes/day		555.00	234.94	176.42	123.10
Capacity per facility	Tonnes/day		555.00	250.00	555.00	1.00
Maximum capacity	Tonnes/day		555.00	250.00	555.00	
Energy production						
Electricity	MWh/year	17,255	0	17,255	0	0
Heat	GJ/year	0	0	0	0	0
Other	GJ/year	0	0	0	0	0
Environmental performance						
Greenhouse gasses	tonnes CO2-eq/year	45,344	0	0	45,344	0
NOx	kg/year	25,496	0	25,496	0	0
SOx	kg/year	2,398	0	2,398	0	0
Particulate matter	kg/year	23,614	0	0	23,614	0
uPOPs uncaptured	kg/year	0.0550	0.0000	0.0000	0.0550	0.0000
uPOPs captured (bagged)	kg/year	0.0000	0.0000	0.0000	0.0000	0.0000

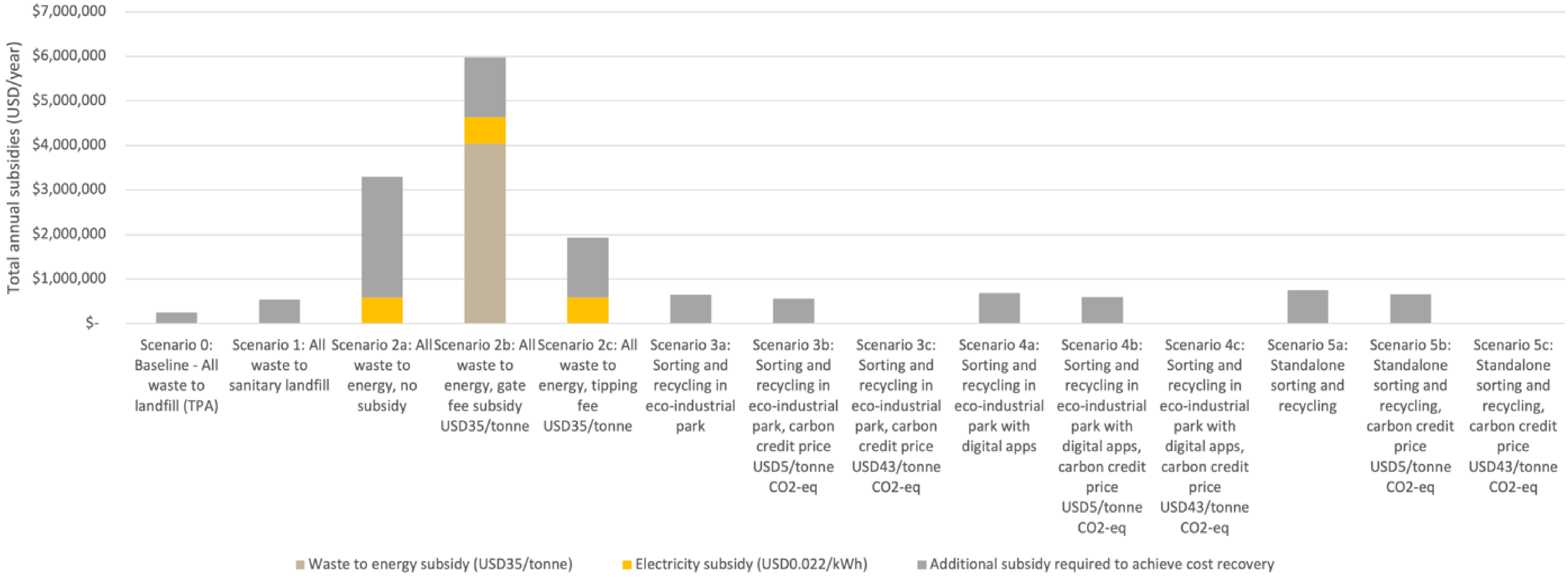
Screening Example – Waste Flow Simulation



Simulation by ADB WARPS tool

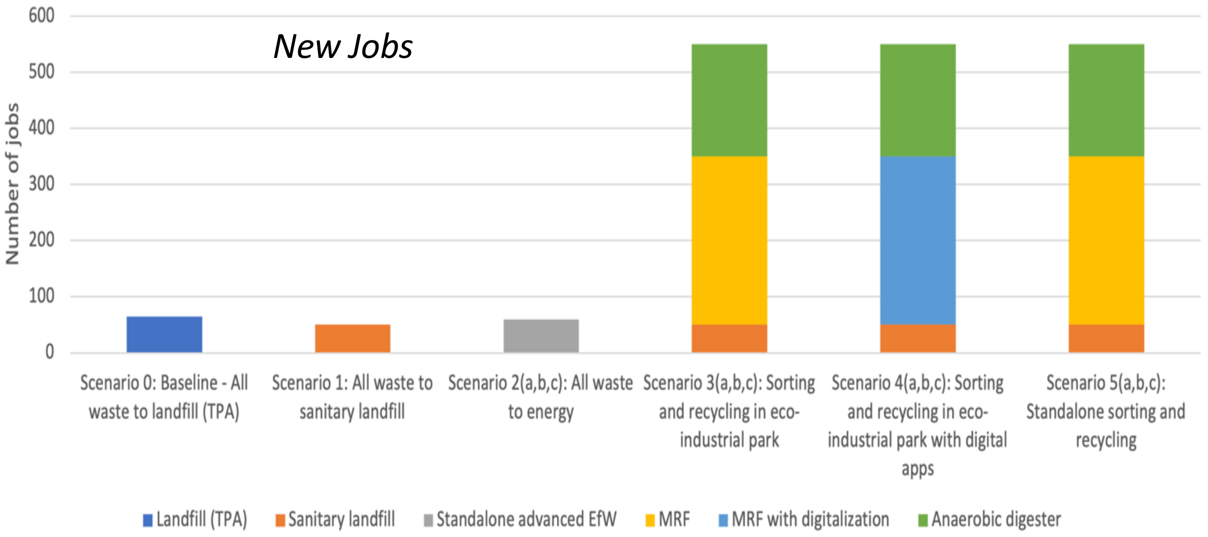
Screening Example – Impacts of Flow Scenarios 1

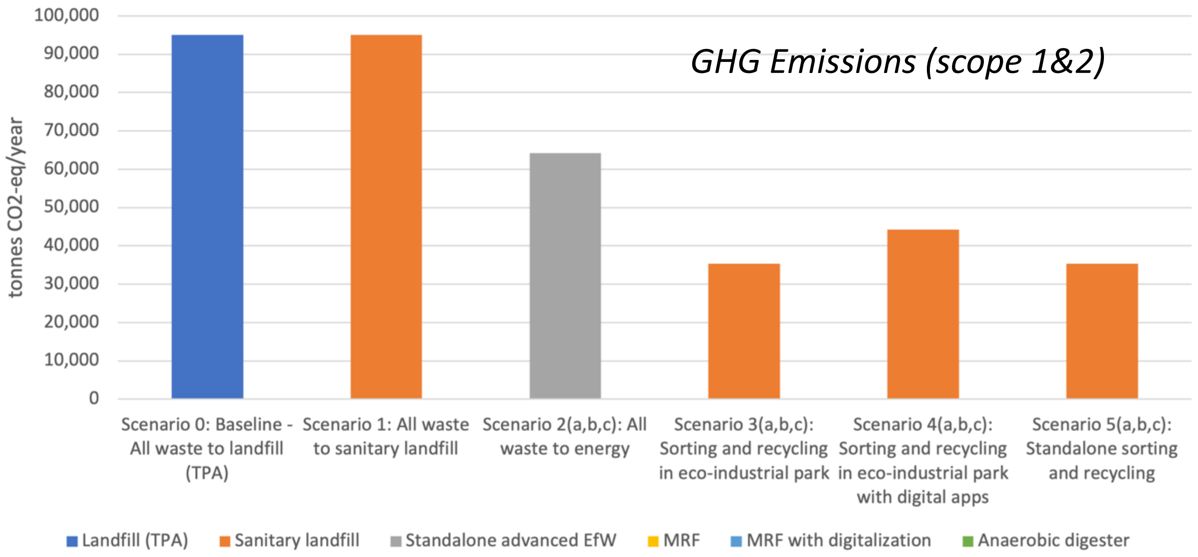
Annual Subsidies for five technology and business model scenarios

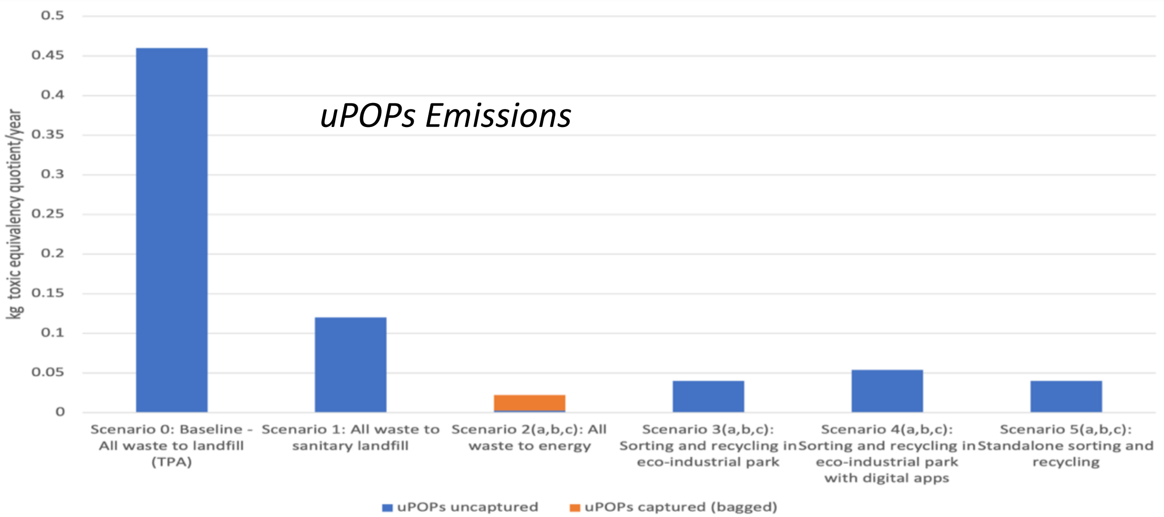


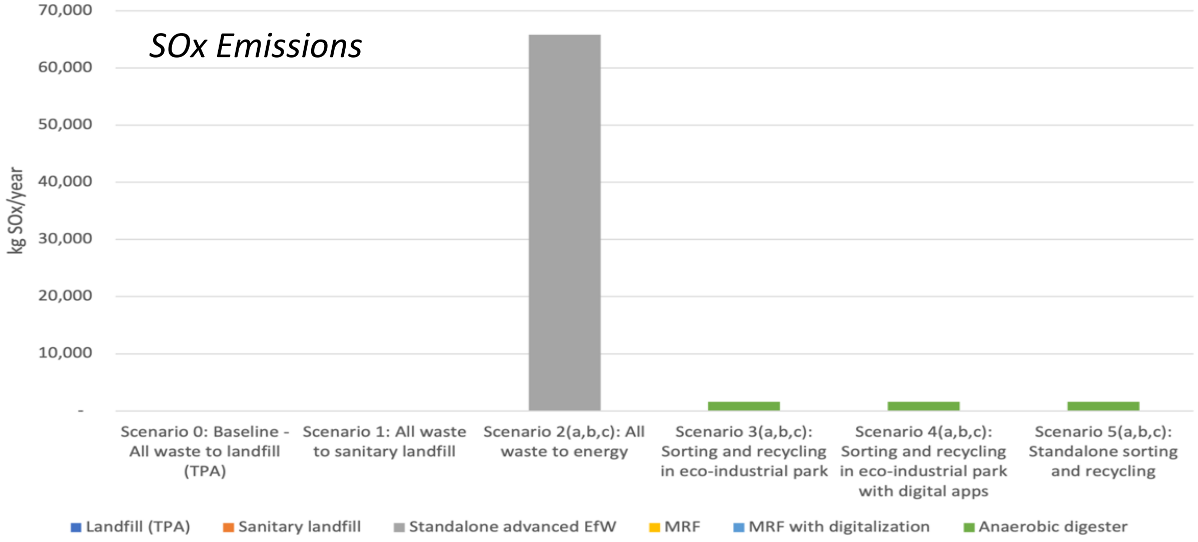
Simulation by ADB WARPS tool

Screening Example – Impacts of Flow Scenarios 2



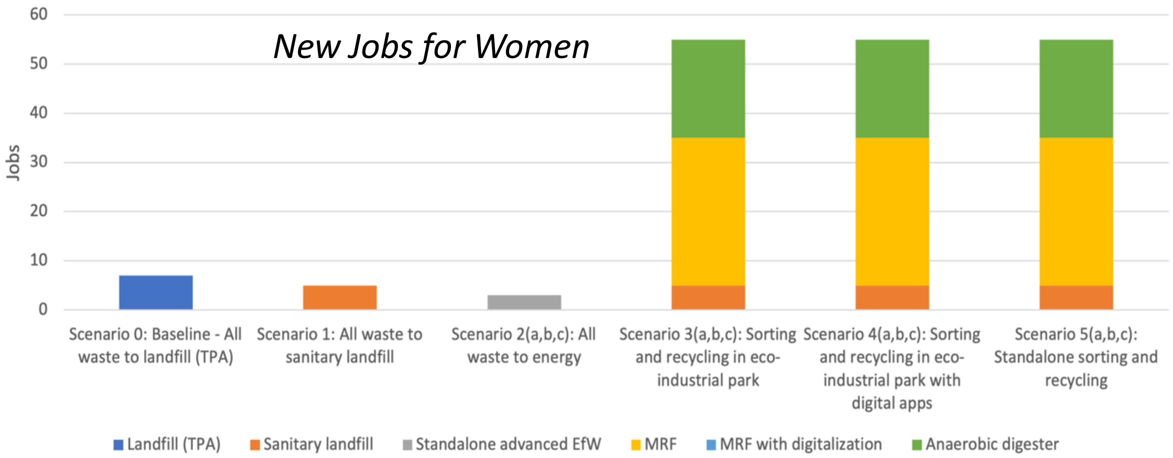


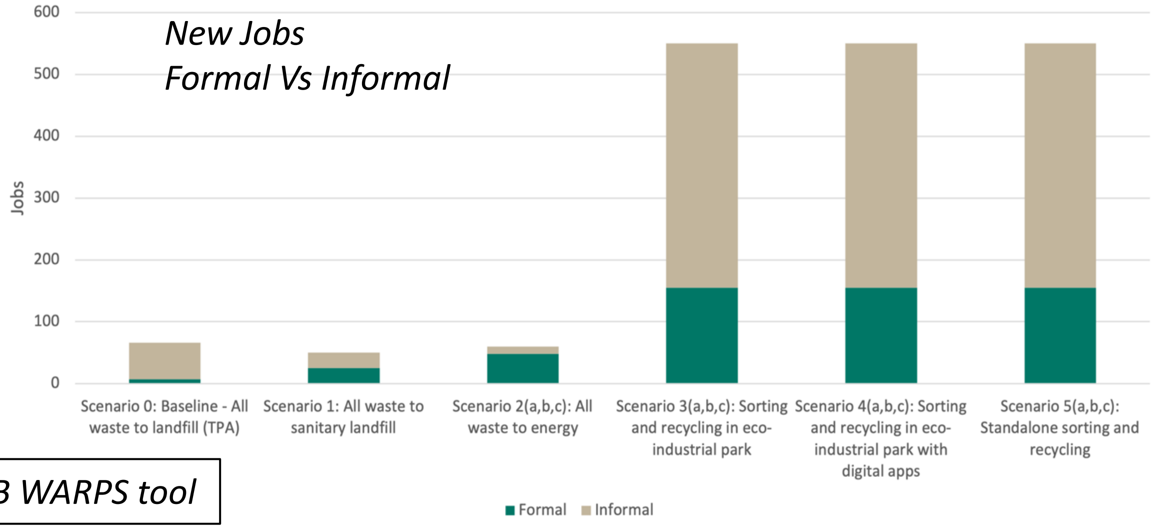




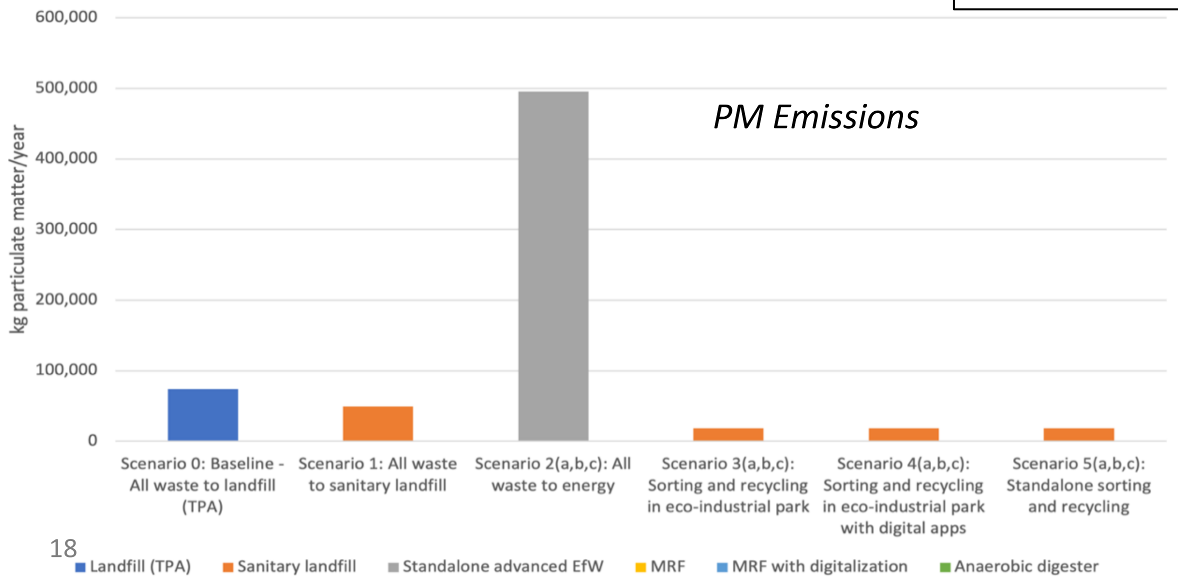
Simulation by ADB WARPS tool

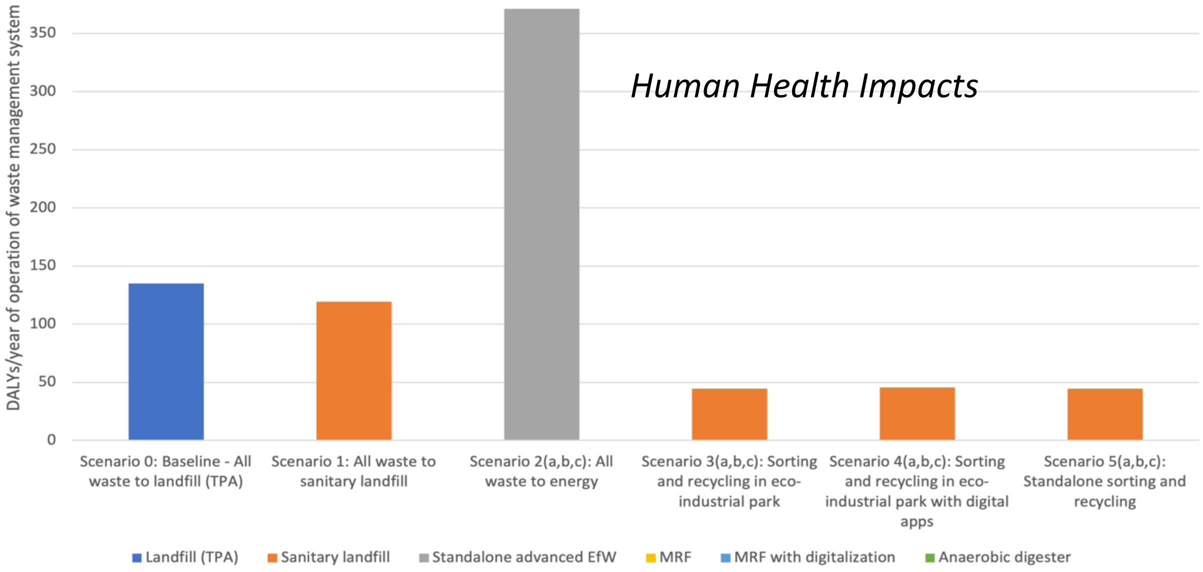
Screening Example – Impacts of Flow Scenarios 3





Simulation by ADB WARPS tool

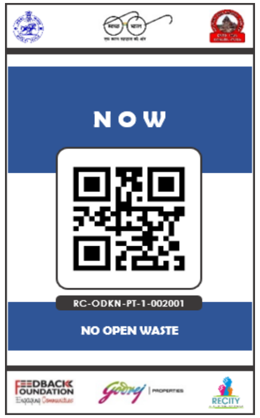


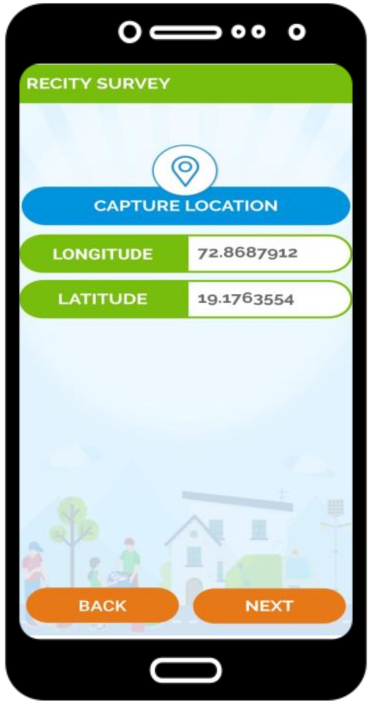


Outcome of Screening with WARPS

- **Rapid simulation** of project scenario(s) using WARPS Tool under beta testing. Note mass and waste character changes will change the outcomes. Denser urban areas with high waste volumes will better suited to EfW processing of unrecyclable mixed waste depending on context.
- Ability to handle complexity, **context**, technology types, waste character, waste volumes and incremental changes in overall service delivery.
- Supportive and engaging to create better outcomes for ADB clients and stakeholders. Not a replacement for Detailed Feasibility Studies.
- ADB recognizes the support of the Australian Department of Foreign Affairs and Trade for the funding support for this study through the Australia ASEAN Smart Cities Trust Fund.

Mobile APPs - Study of RECITY Waste APP





Geo Tag Property Units

Daily Covid Waste Collection

Transfer To Waste to Energy Facility

Record Of Waste To WTE Facility

Note: Mobile application in local language - Odia

Artificial Intelligence Applications

AI is Ubiquitous in modern life from airline booking bots to machine learning algorithms used optical character recognition….(and ChatGPT!)

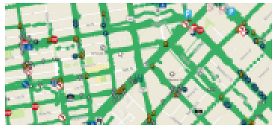
Emerging AI applications can query a large data set to discern patterns which may not be evident. Enhanced ability to demonstrate feed stock for recycling, reuse and energy recovery.

This might include the linking of waste pickup trucks with air quality and local sanitation information (i.e. Deep Trasher) to determine areas where enhanced community engagement/enforcement is needed to stop dumping.

Further development AI in ADBs operations under ADB Artificial Lab in collaboration with Amazon Web Services (AWS).

When you think Artificial Intelligence…

Which data collection method to choose?

	CCTV	Update frequency, Human Ressource	Cost, Deployment, Acuracy, Spatial coverage
	Camera on vehicle	Update frequency, Deployment, Acuracy	Human Ressource, Cost
	Smartphone	Deployment, Acuracy, Spatial coverage	Update frequency
	Drone	Acuracy, Spatial coverage	Update frequency, Human Ressource, Cost, Deployment
	Mapillary	Update frequency, Human Ressource, Cost, Deployment, Acuracy, Spatial coverage	Copyright/legal

Criteria

- *Update frequency*
- *Human Ressource*
- *Cost*
- *Deployment*
- *Acuracy*
- *Spatial coverage*
- *Copyright/legal*

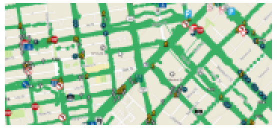
A choice guided by simplicity and low costs

CCTV

Camera on vehicle

Smartphone

Drone



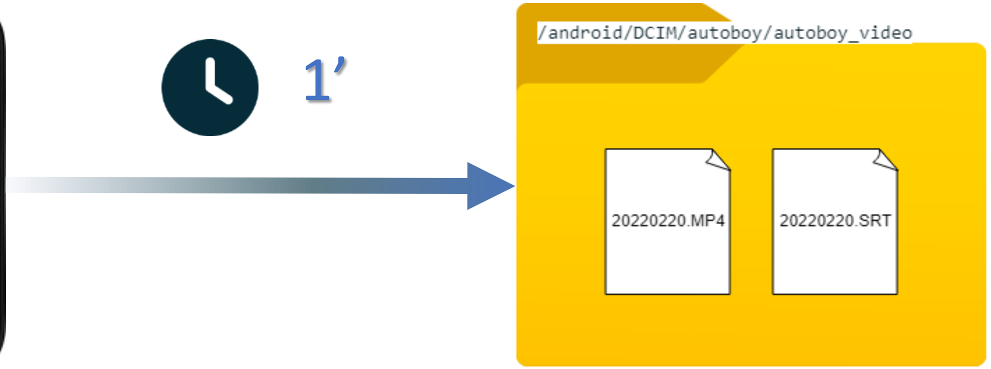
Mapillary

Creating data on-demand

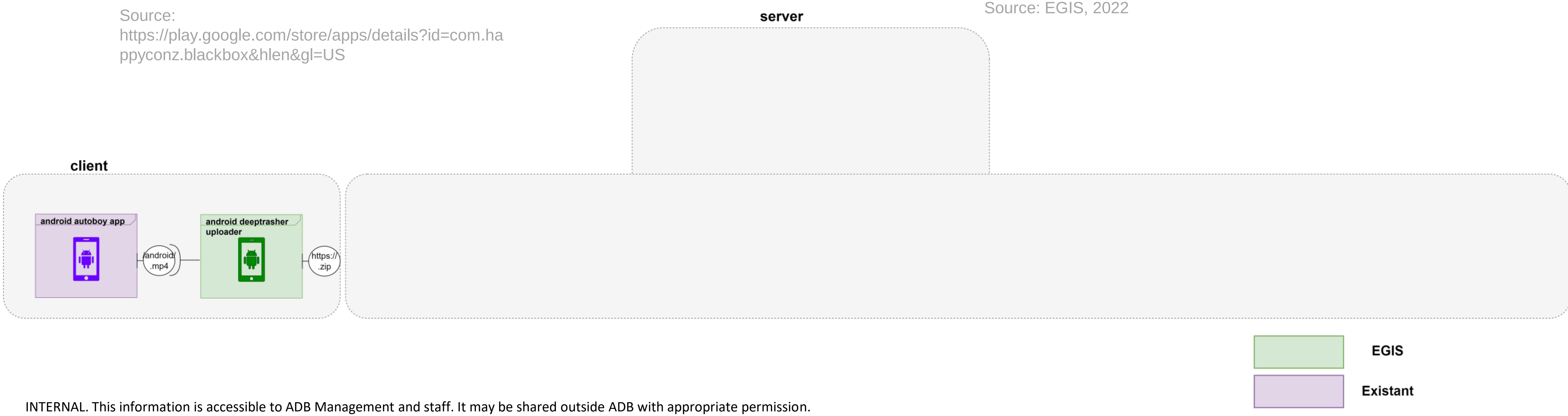
Android Autoboy App

Source: https://play.google.com/store/apps/details?id=com.happyconz.blackbox&hlen&gl=US

Android Deeptrasher Uploader



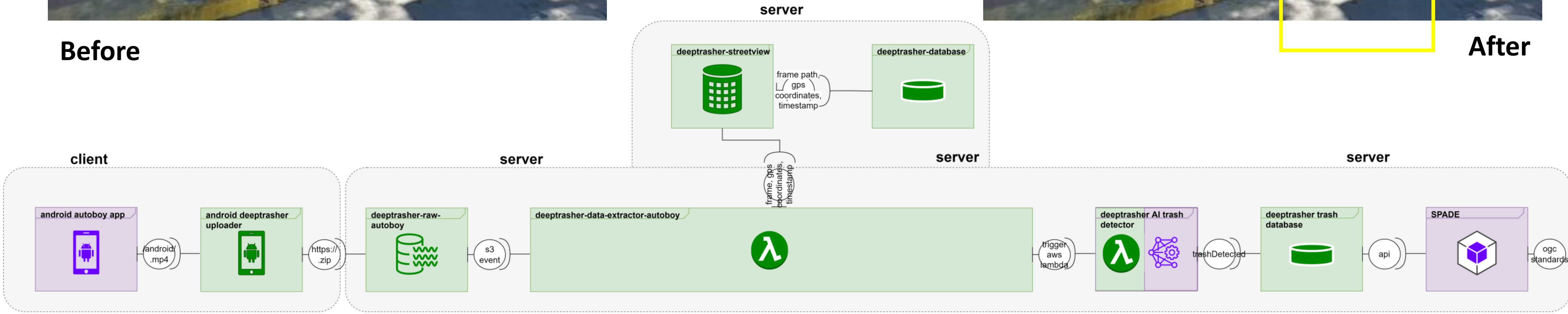
Source: EGIS, 2022



INSTANT IMAGE RECOGNITION

Before

After

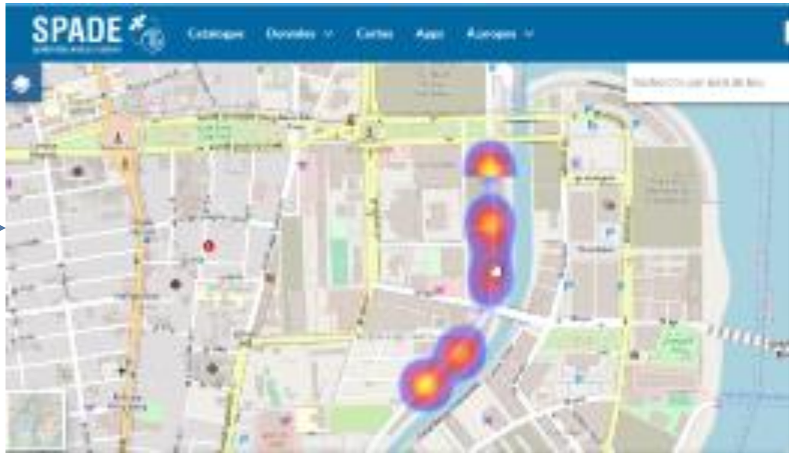


EGIS

Existant

Rendering on ADB SPADE Platform

px² of waste



Heatmap

Grid with cleanliness score

Rendering possible for:

- ✓ **Different time ranges:**
  - ➢ last day
  - ➢ rolling 7 days
  - ➢ rolling 30 days
- ✓ **Worldwide coverage**

Next Steps

Future actions:

- ✓ Integrating a number of non-AI applications with AI enable applications to build a suite of tools for ADB Developing Member Countries under ADB AI Lab (in collaboration with AWS).
  a. Simulate waste supply chains and game various scenario for solutions.
  b. Track the performance of waste supply chains and link outcomes from Deep Trasher to planning scenarios.
  c. Query data for opportunities for localized recycling, upcycling or business process changes to reduce cost and increase amenity.
  d. Integrate solution into wider circular economy value chain.
  e. Integrate Extended Produce Responsibility Platforms with AI to query outcomes and optimize economic, social and environmental outcomes.

Digitizing the Circular Economy – EPR – Extended Producer Responsibility

Platform & APP linking import/sale, location & treatment charge (TC)/subsidy (S) over product lifecycle

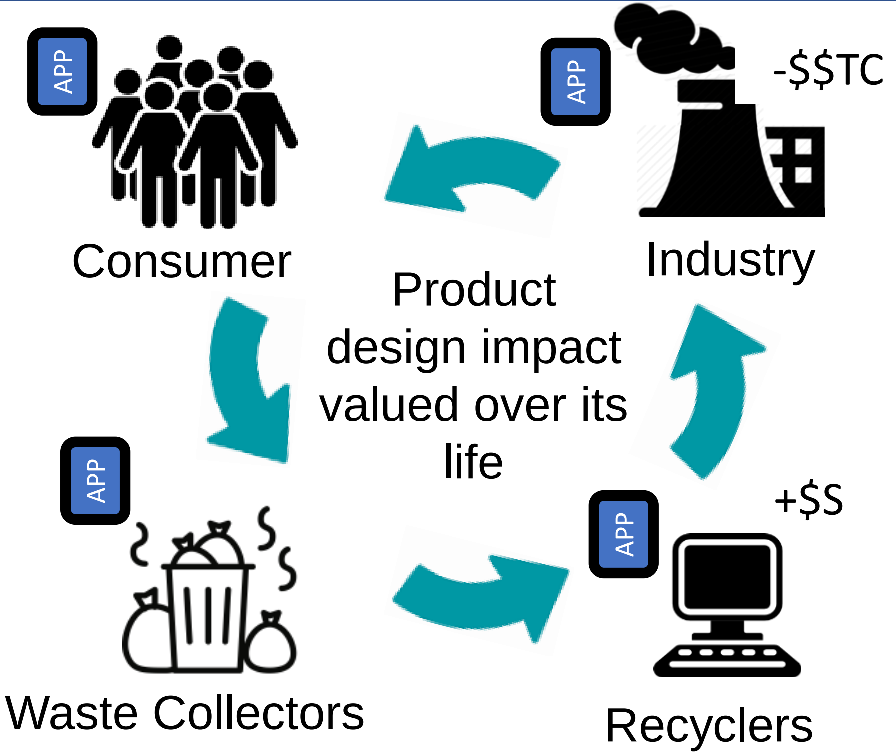
<u>Government</u>
Create regulatory environment, owns platform, collects revenue (TC) & disburses subsidy (S)

Policy, Regulation, Taxation & Subsidy

Changes deployment of capital to more attractive subsidized waste activities & low impact FMCG companies

Capital with Confidence

Enforcement



End of Life facility provider paid a flat toll charge, removing perverse incentive to burn – encourages recyclers

End of Life Technology

Waste managed to be within ecosystem services boundary

In Conclusion

- Digitization is the “low hanging fruit” for Energy and Waste.
- The use of satellite based data, especially remote sensing of CO_2 and CH_4 will bring waste and energy practice into wide view. Blog here.
- Moving along the digitization pathway allows for acceleration in our efforts on Just Energy Transition. Blog here.
- Many of you will have already embarked on this journey whilst others are not yet mobilized. I wish you well on your journey.
- Thank You

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