Sustainable Waste to Wealth : Options and Challenges

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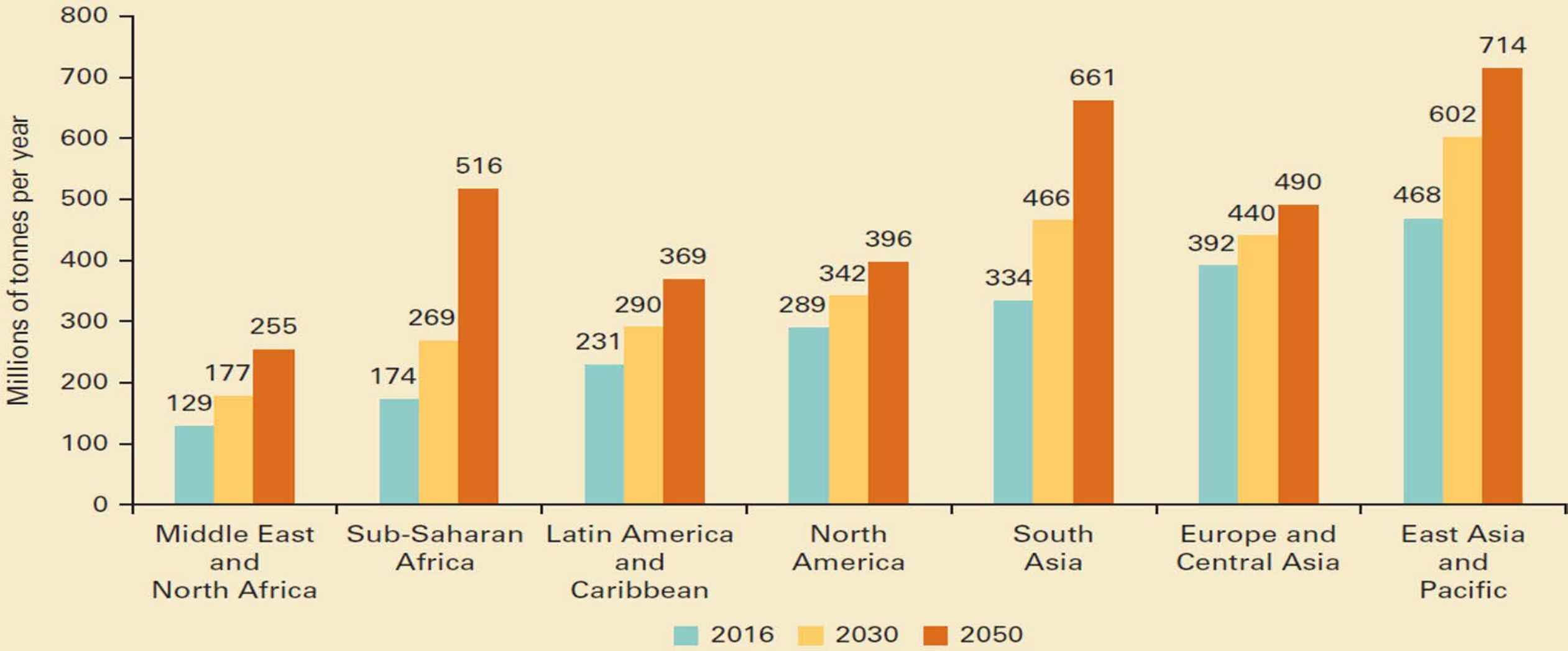
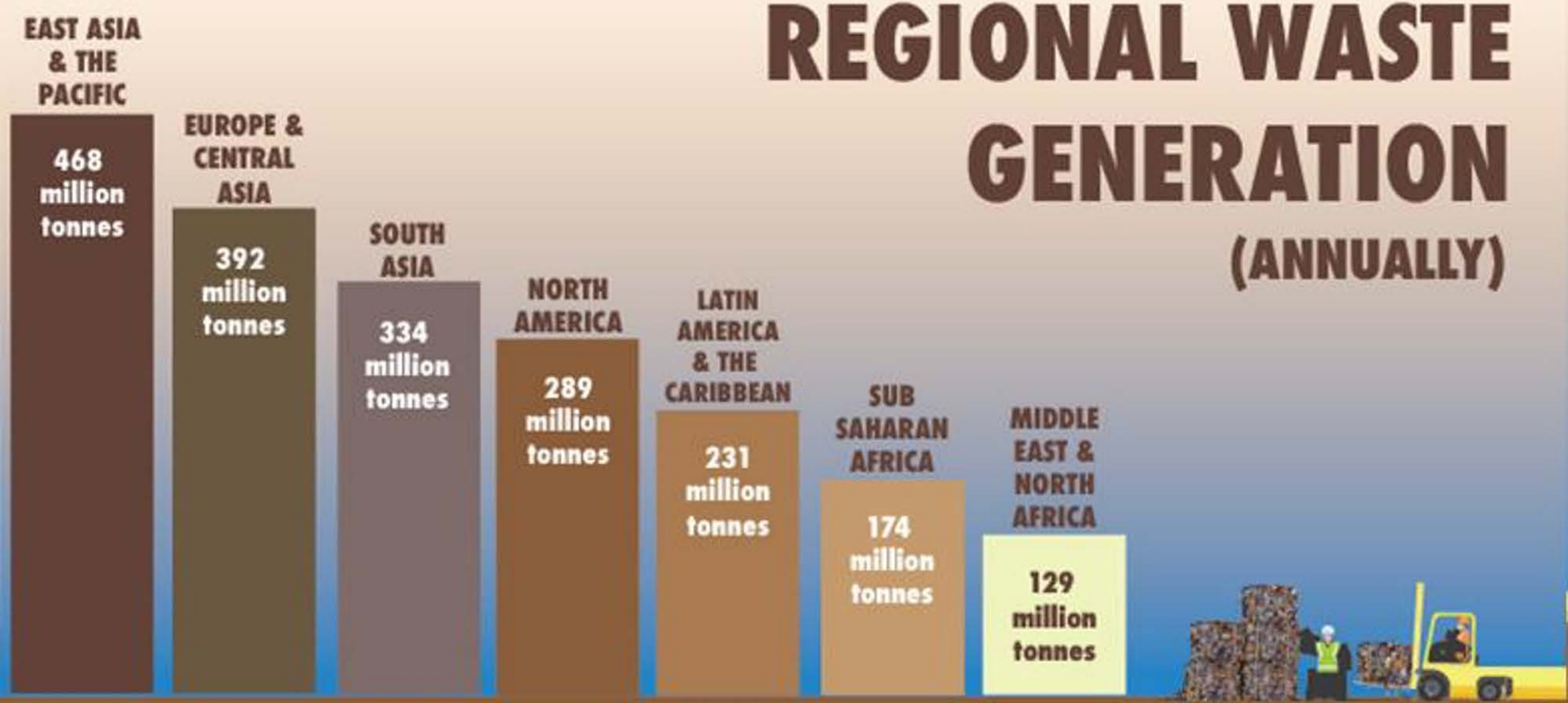
Waste to Wealth

Global Waste Generation

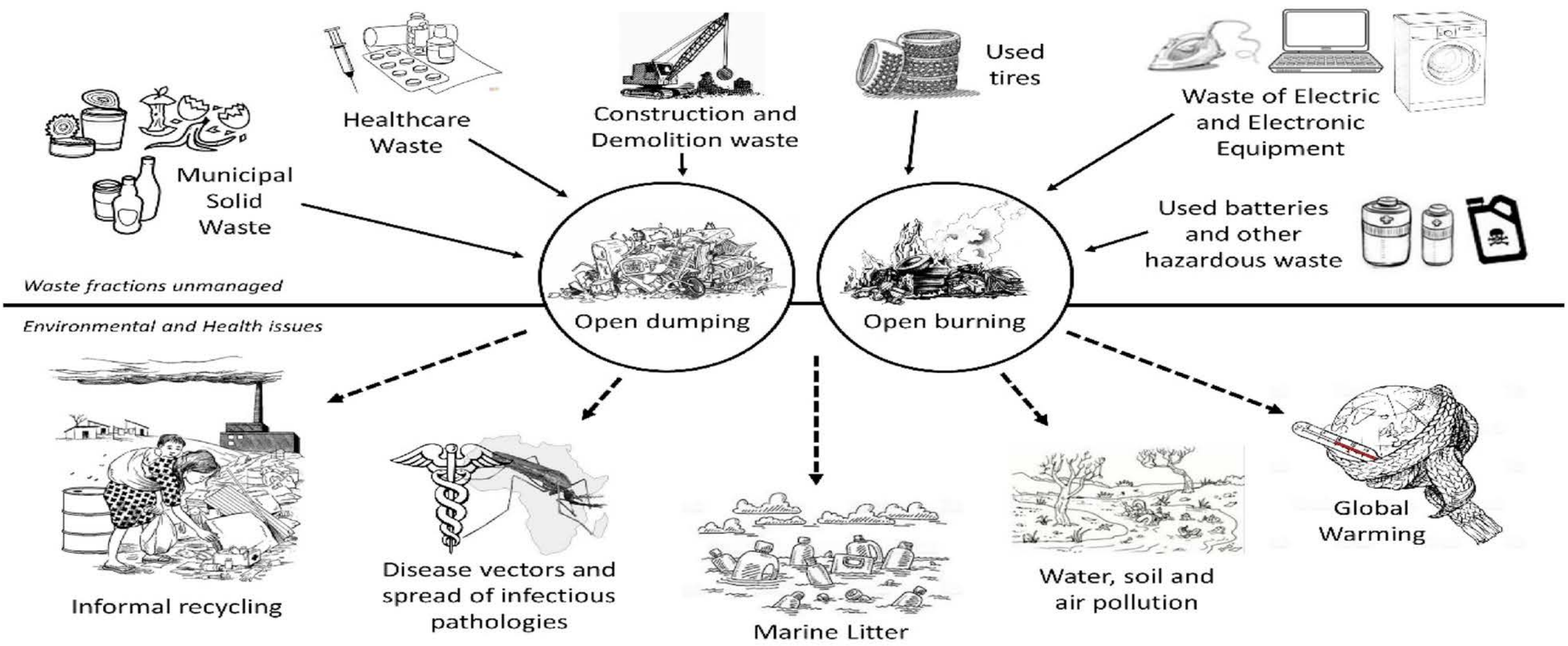


REGIONAL WASTE GENERATION (ANNUALLY)



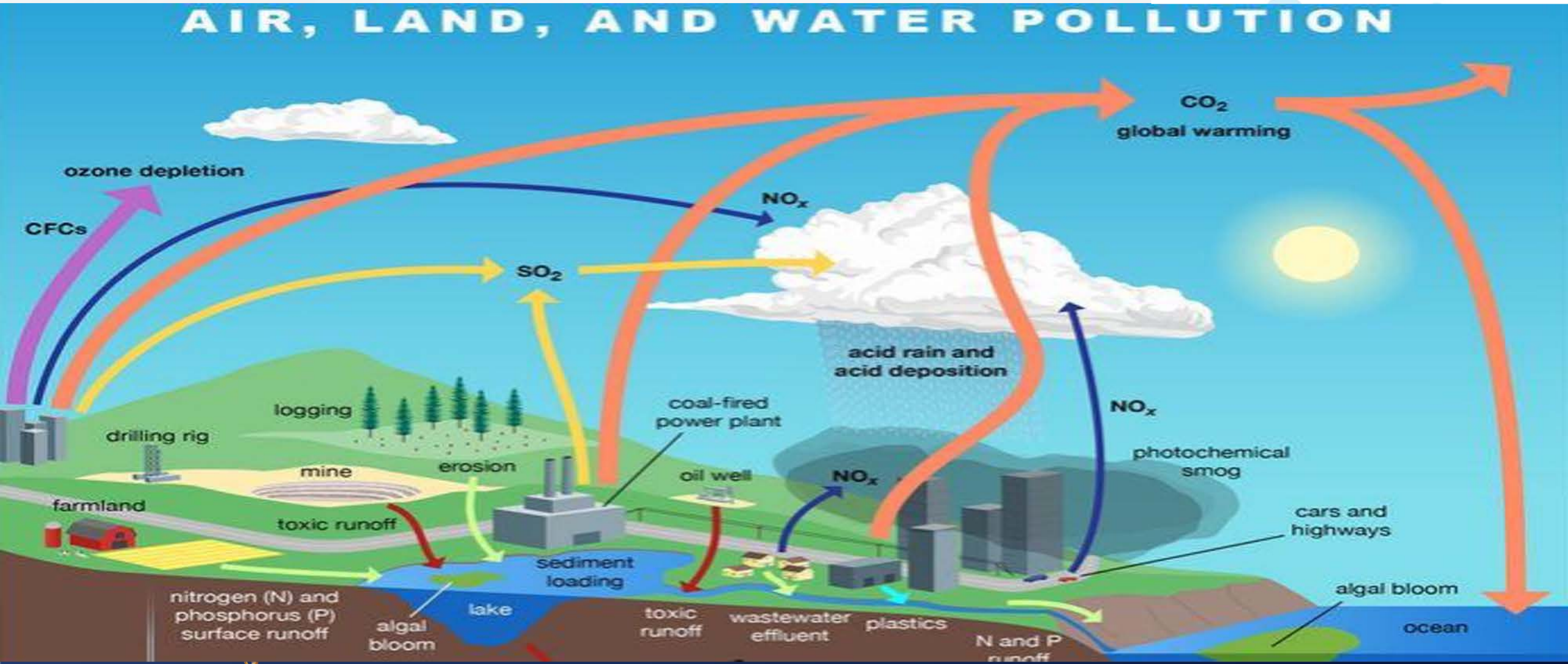
#WhatAWaste2 | worldbank.org/what-a-waste

Solid Waste Mismanagement.




In low-income countries, over 90% of waste is mismanaged.
This increases emissions and disaster risk,
which affects the poor disproportionately.
1/3 (extremely conservative) of solid waste is openly dumped or burned
In low-income countries, waste management costs comprise 20% of municipal budgets on average
We will LITTERally be living in waste if nothing is done.
What can we do?
worldbank.org/what-a-waste
#WhatAWaste2
Data Source: World Bank (2018)
Images: Lois Goh, World Bank, Shutterstock

Environmental concerns



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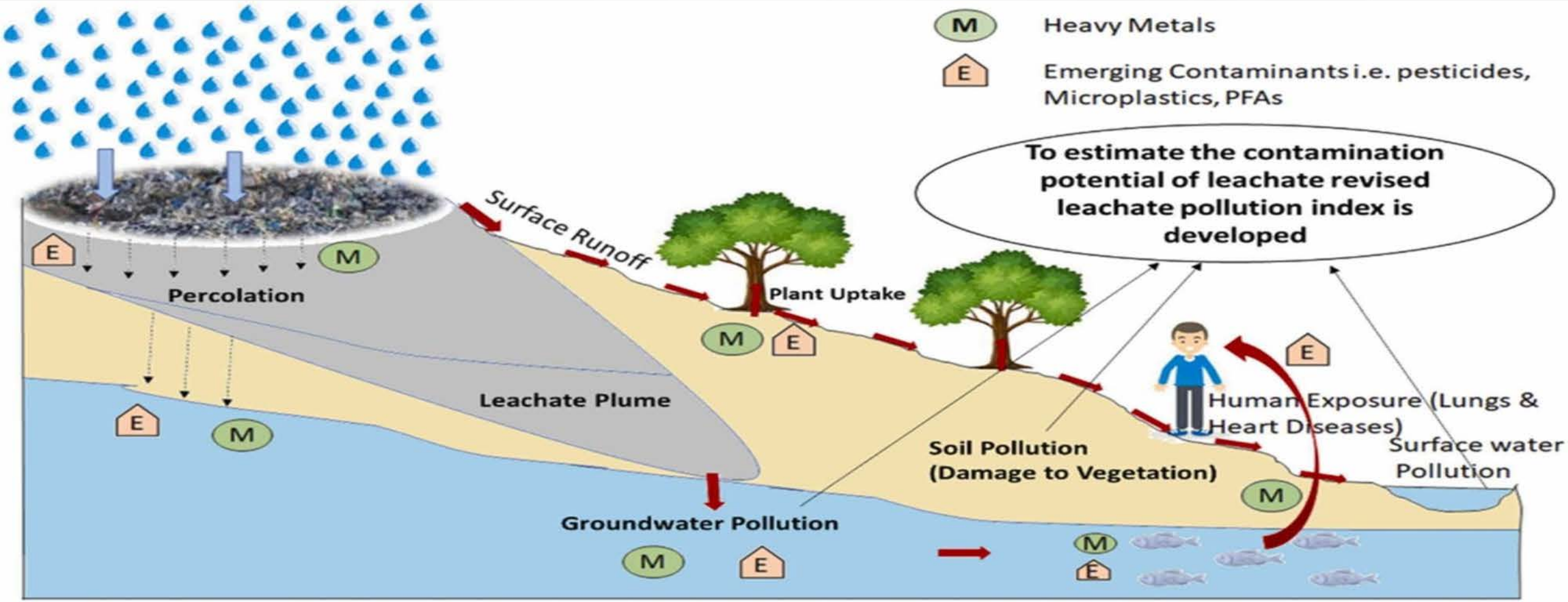
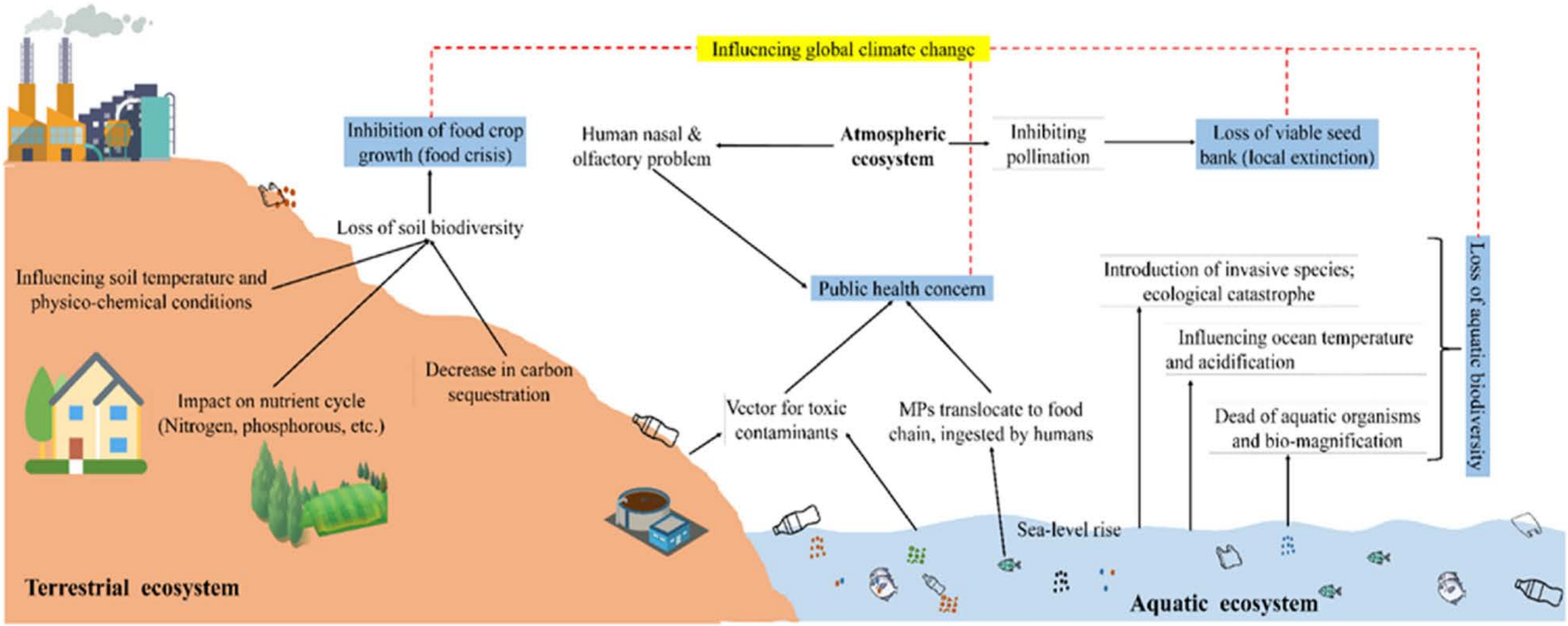


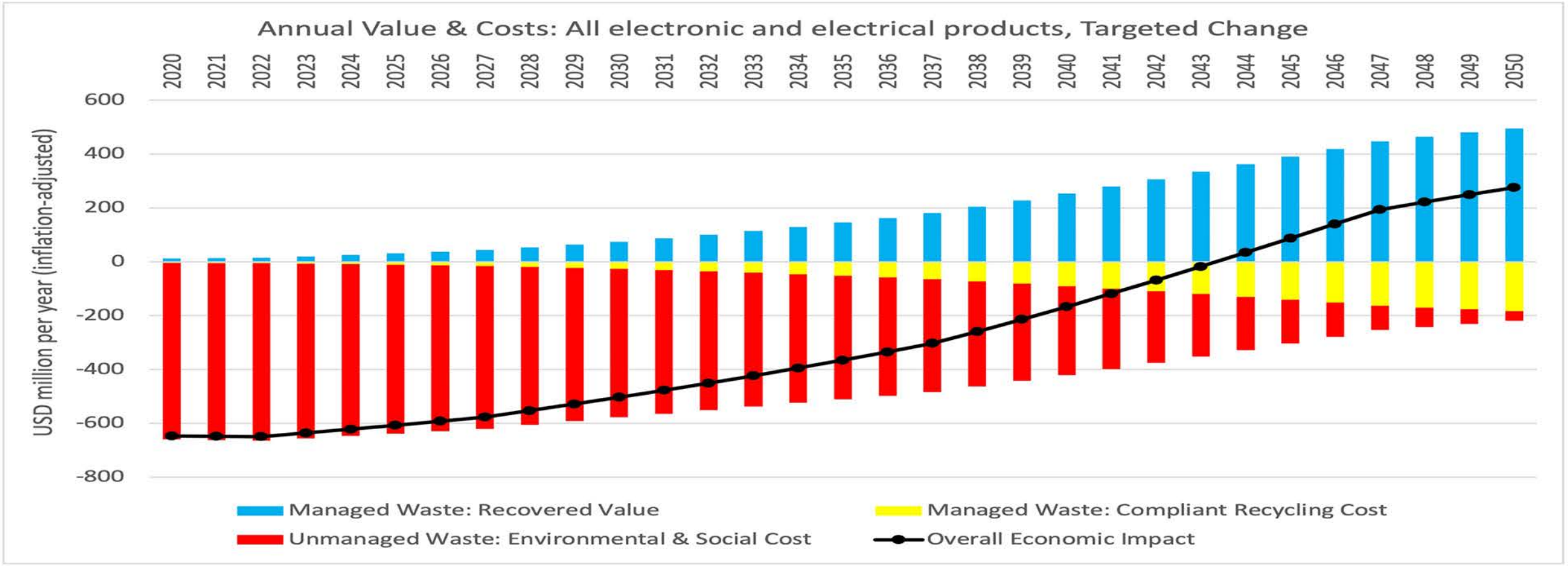
MPs and NPs Affect Ecosystems and Climate



Economic Impact

Annual Value & Costs: All electronic and electrical products, Targeted Change

Units: **USD million per year (inflation-adjusted)**



TYPES & SOURCES OF INDUSTRIAL WASTE

Types:

- Process waste and Non-Process waste
- Hazardous: Includes toxic, corrosive, or reactive materials.
- Non-Hazardous: Such as scrap metals, packaging, and construction debris.

Sources:

- Manufacturing: Textiles, electronics, chemicals.
- Construction: Cement, wood, and metals.
- Mining & Agriculture: Organic waste, mining by-products.

Loss of Resources

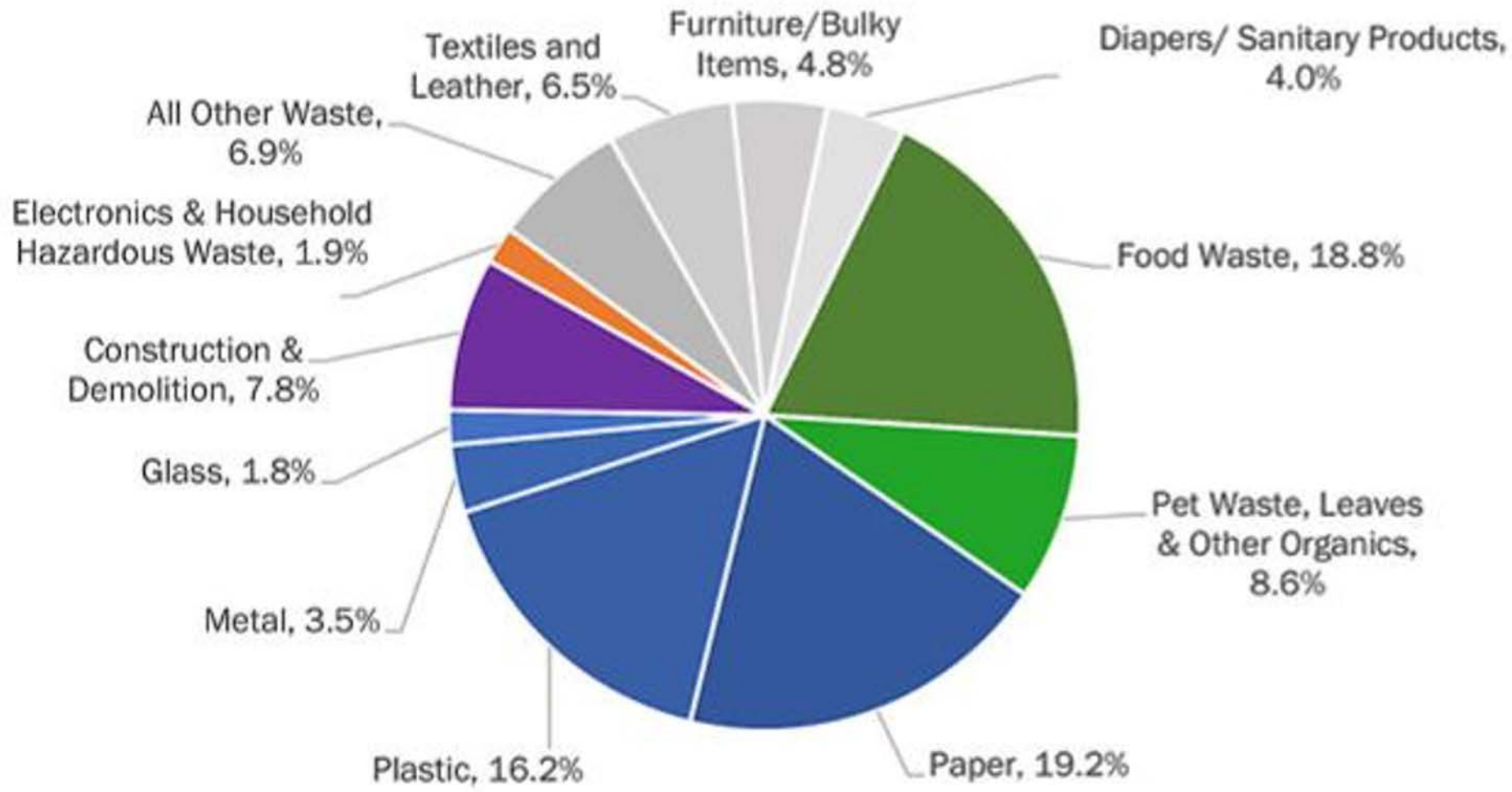
Category	Impact	Global Value
E-Waste	$57.4 billion in raw materials lost	17.4% recycled
Plastics	9% recycled, 91% wasted	Billions in recyclable material lost
Food Waste	$750 billion in annual losses	1.3 billion tons wasted
Energy Waste	$6 billion lost from non-recycling	Energy savings from recycling metals
Circular Economy Potential	$4.5 trillion annually by 2030	Missed opportunity

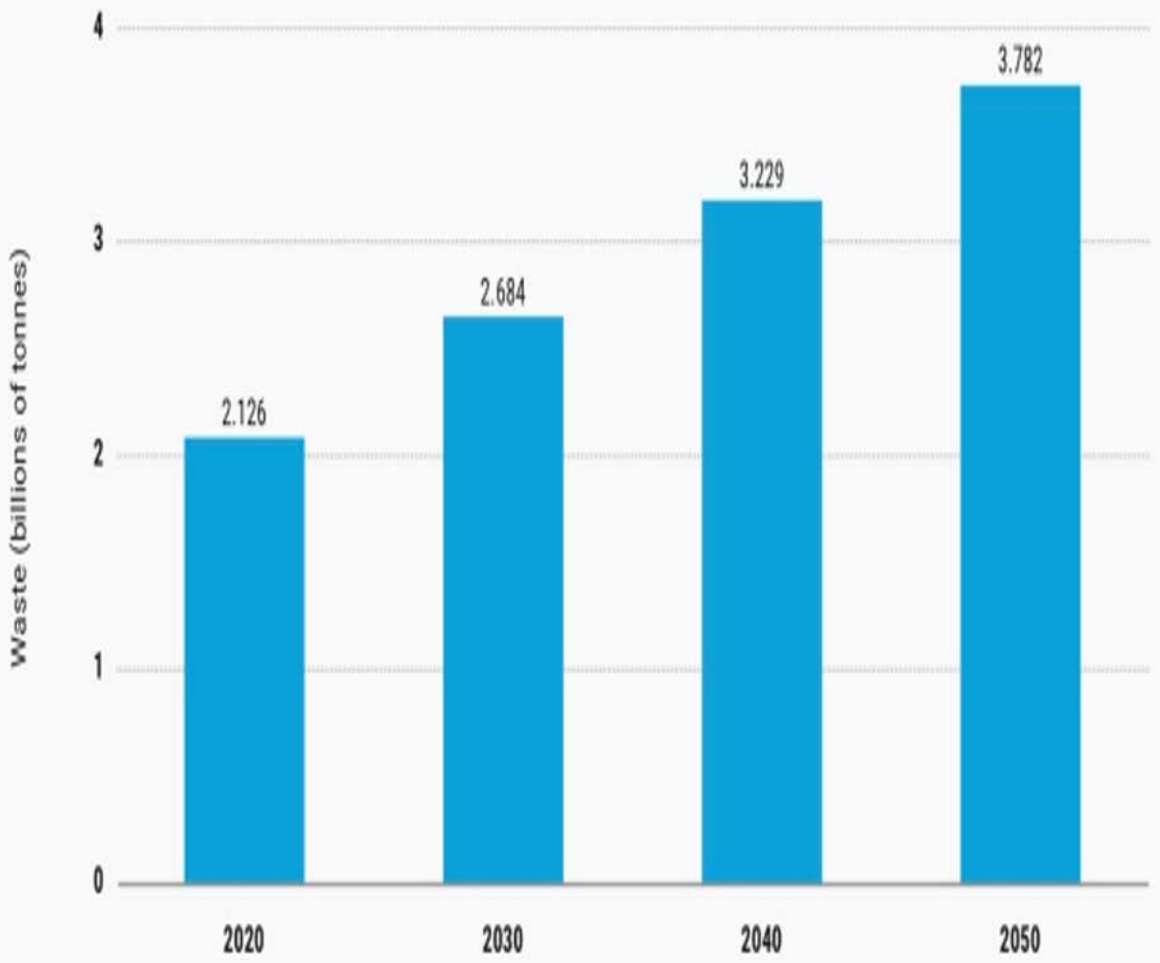
Costs of Improper Waste Handling

Category	Impact	Global Value
Landfilling Costs	$30–100/ton	$200 billion/year global cost
Environmental Cleanup	$13 billion annually (plastic waste)	N/A
Health Costs	7 million premature deaths annually	Healthcare costs up by 10–20%
Tourism & Property Impact	Tourism loss: 10–15%	Property value drop: 5–10% near landfills

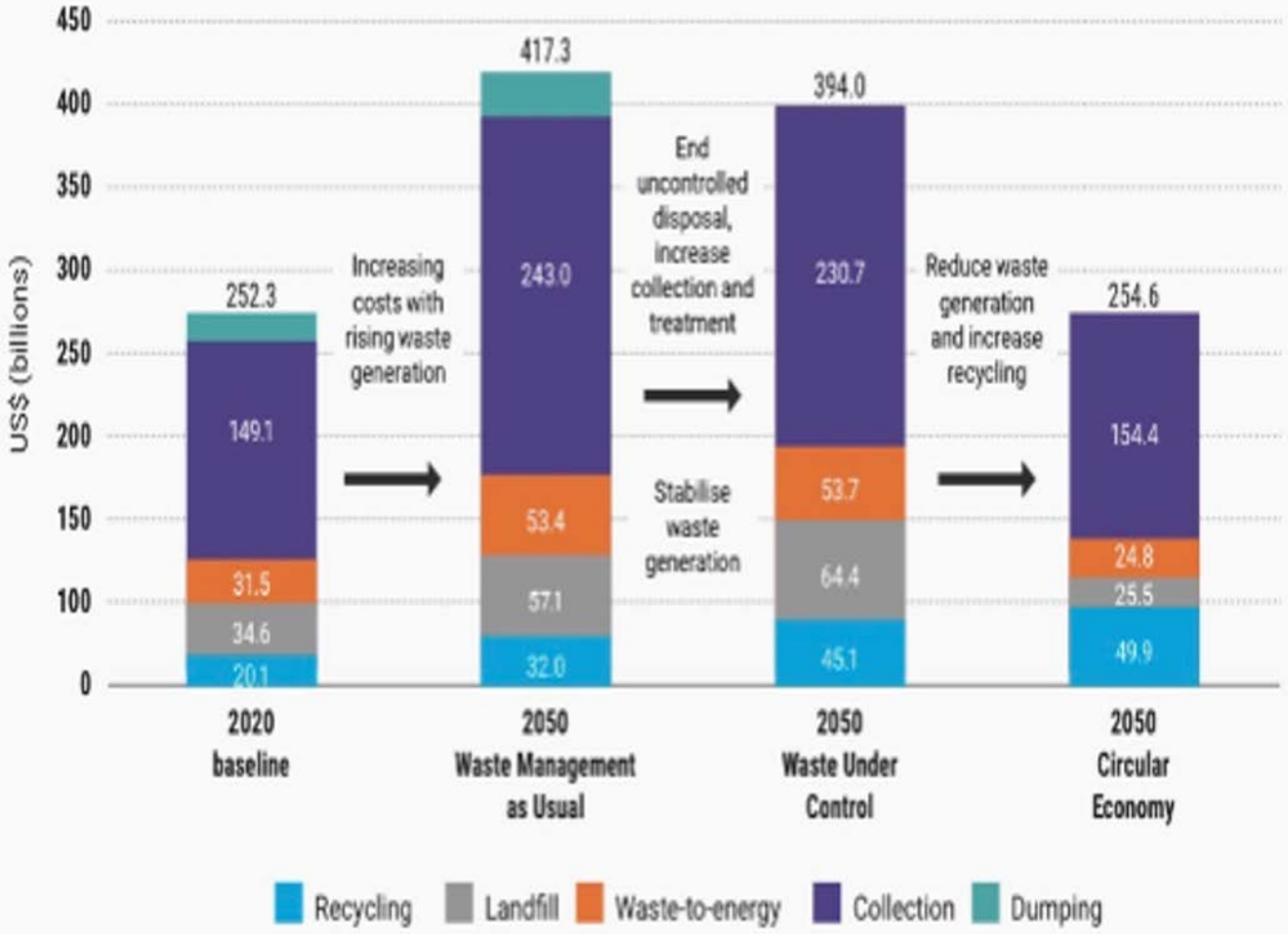
Understanding Waste

Composition of Waste



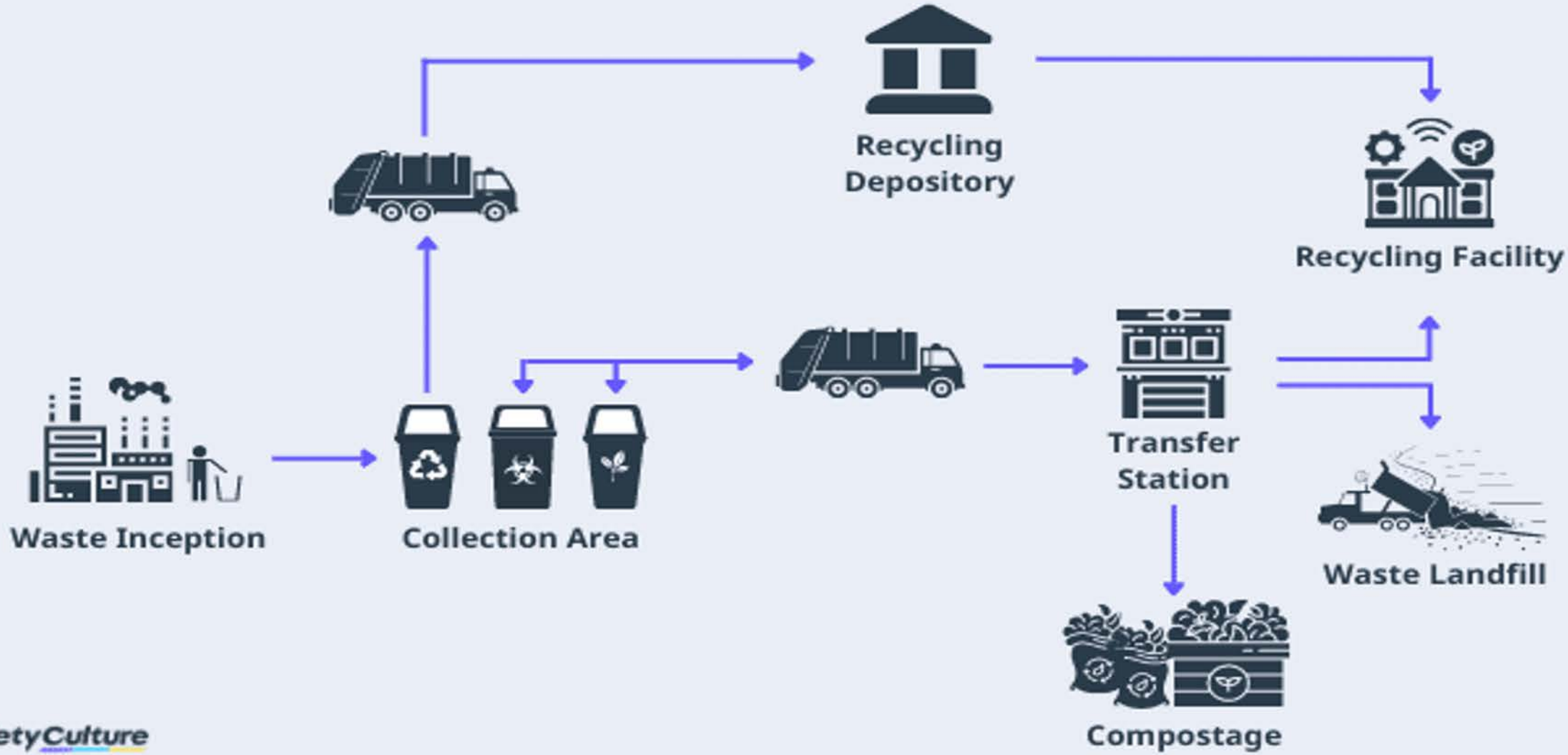


Projections of global municipal solid waste generation per year in 2030, 2040 and 2050 if action is not taken
Source: GWMO 2024



Global direct costs of municipal solid waste management in 2050 under the three scenarios
Source: GWMO 2024

Waste Management Life Cycle



CURRENT SITUATION & CHALLENGES

- **Rising Waste:** Industrialization has led to increasing waste generation, especially in urban centers.
- **Environmental Issues:** Improper disposal leads to pollution, affecting soil, water, and air quality.
- **Government Initiatives:** Programs under Malaysia's Department of Environment, like waste-to-energy projects and stricter enforcement on hazardous waste disposal.

Sustainable Waste Management

- Unmanaged waste causes pollution, contributing to **20% of global methane emissions** from landfills.
- **13%** of global municipal waste is currently recycled; leading countries recycle over **60%**.
- Recycling **1 ton of paper** saves **17 trees** and **7,000 gallons of water**.
- Landfills account for about **5% of global greenhouse gas emissions**.
- Diverting organic waste through composting could reduce **25-30%** of municipal waste.
- The recycling industry is valued at over **$200 billion** and employs **20 million** people globally. (Amanor-Wilks & Amanor-Wilks, 2024)

Environmental and Economic Impact

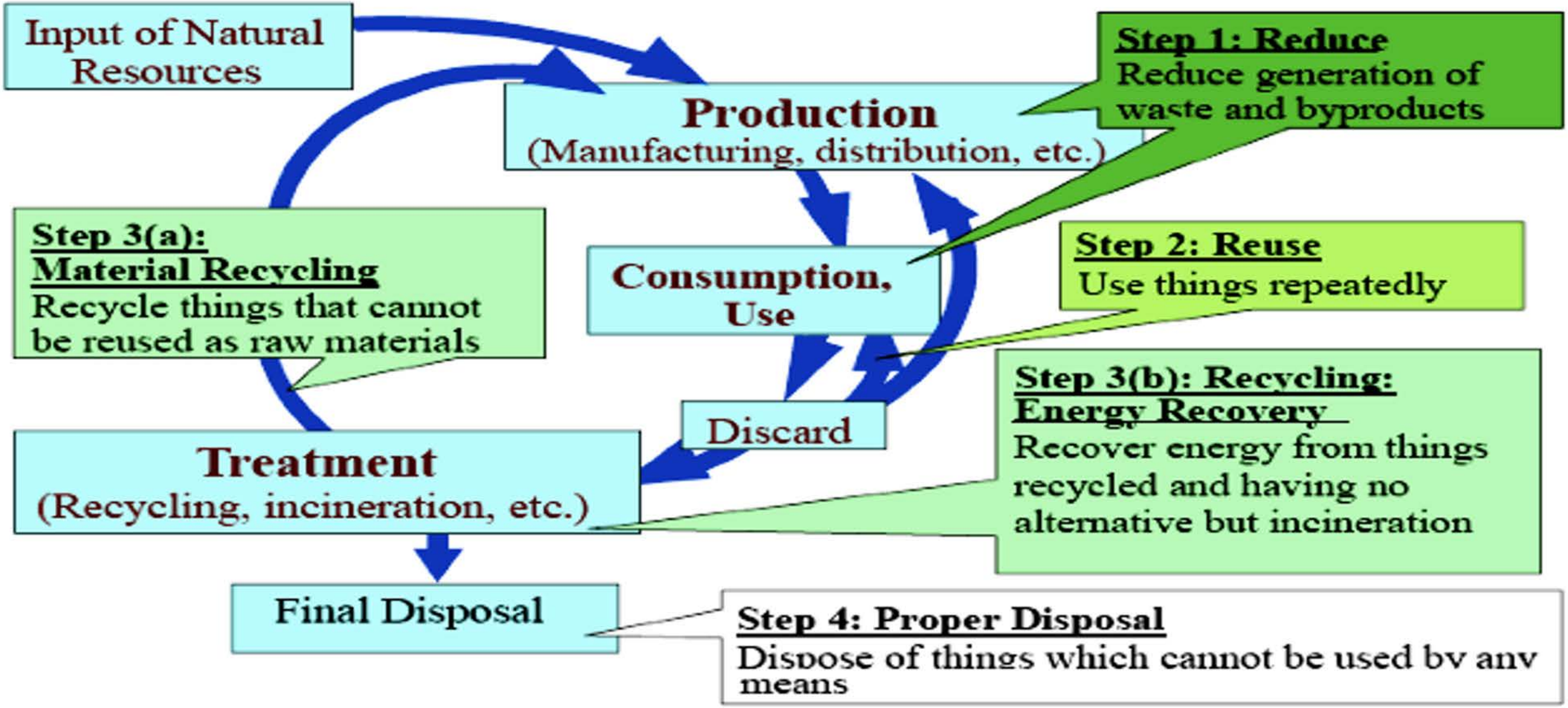
Implementing waste-to-worth initiatives can significantly reduce landfill use, with the potential to divert **60-70%** of waste from landfills.

This process can lower greenhouse gas emissions by **1,100-3,000 Mt CO2e** annually through improved waste management and soil carbon sequestration.

The global market for biomass and waste-derived products is expected to grow by **10-15%** annually, creating significant economic opportunities.

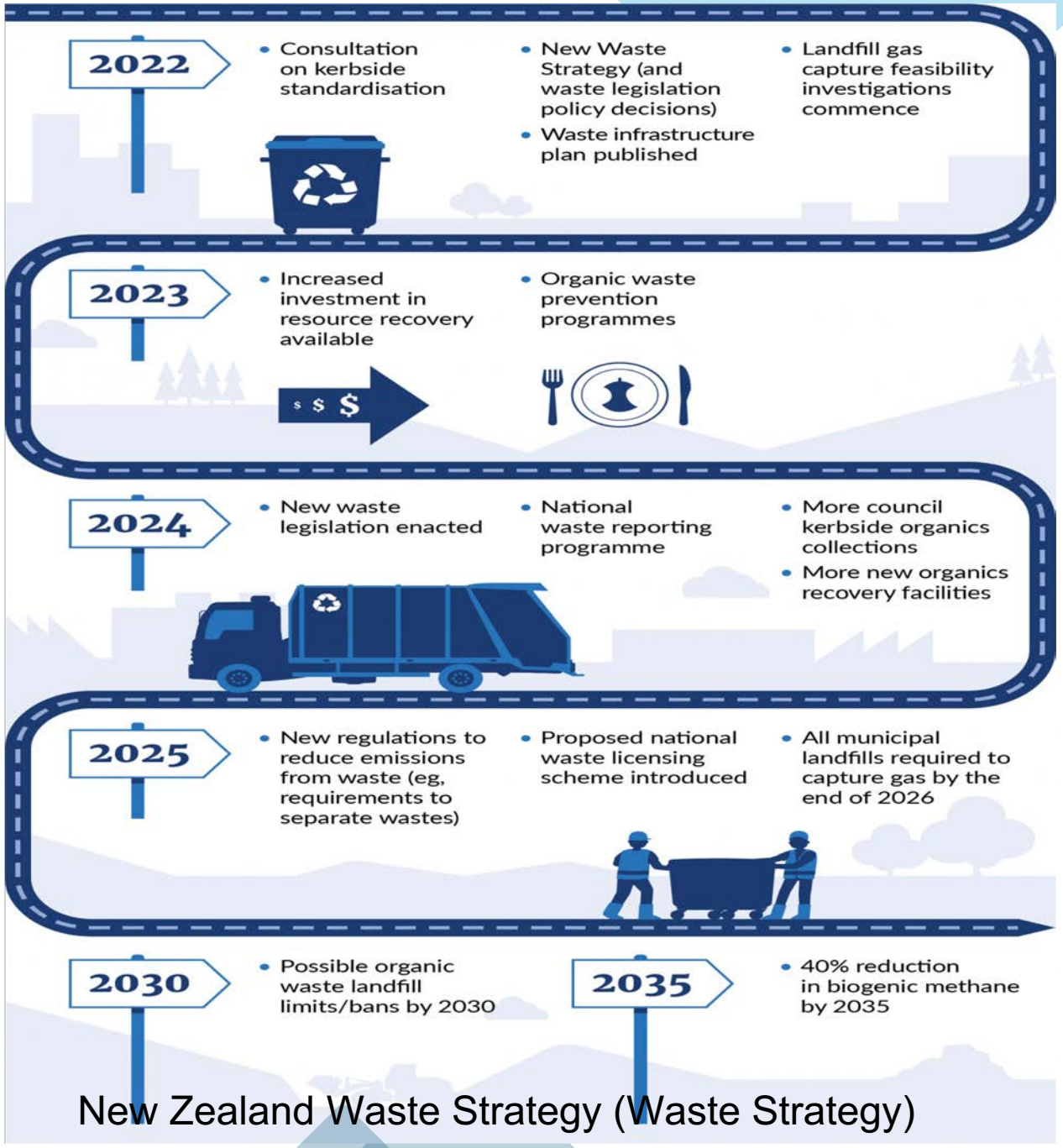
The transition to waste-to-worth strategies could generate **$300 billion** in new economic activity globally by 2030.

Concept of the 3Rs in a Sound Material-Cycle Society



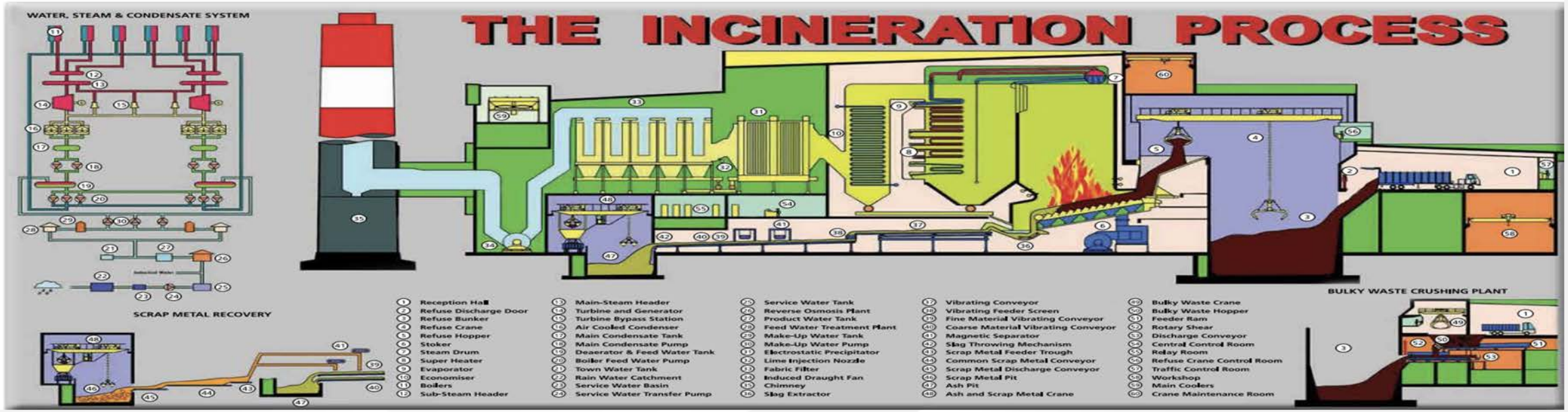
Waste Pathway to 2035

- Targeting waste emissions will support the shift to a circular economy
- To reduce our biogenic methane emissions from waste
- Strategic changes will support emissions reductions.
- Efforts to reduce waste emissions must focus on organic waste.



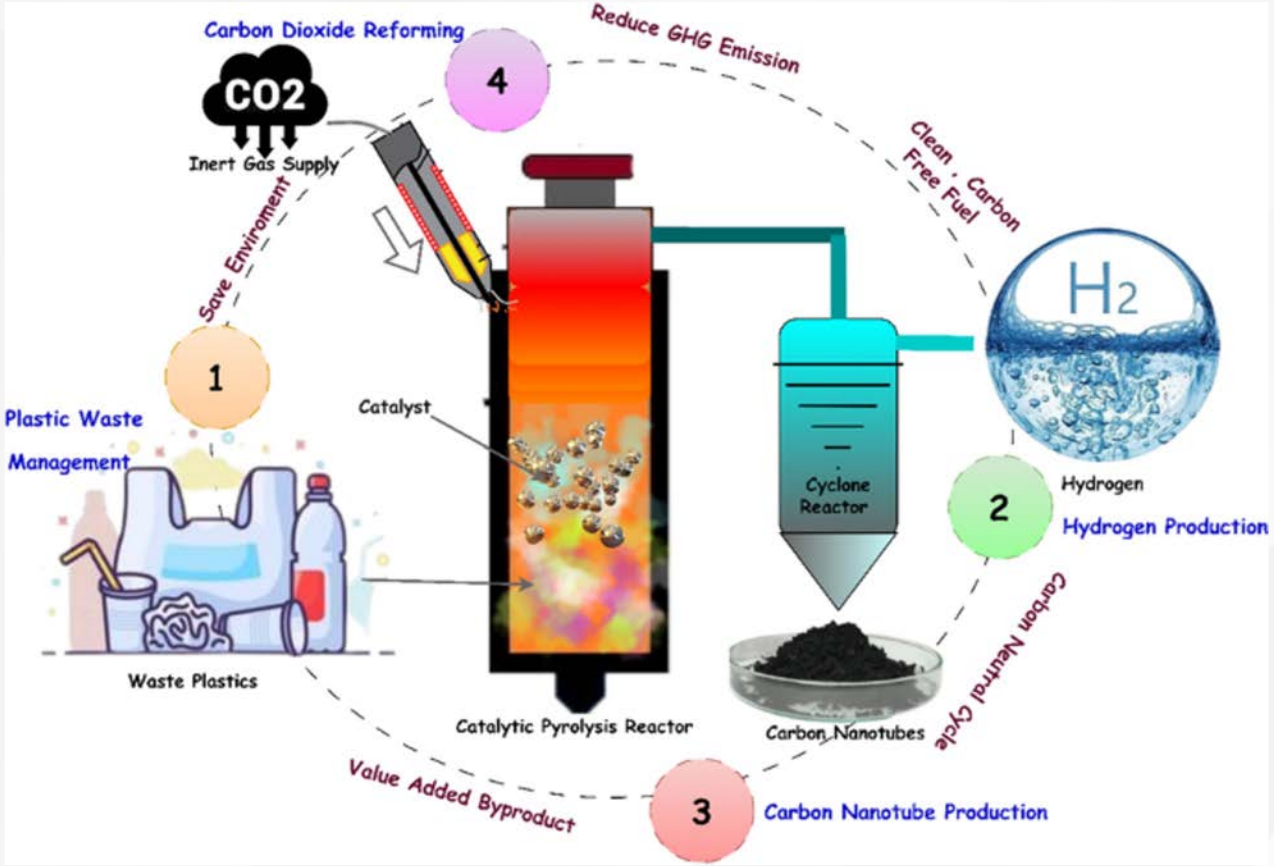
New Zealand Waste Strategy (Waste Strategy)

Waste to Energy (W to E)



- Waste is converted into electricity or heat through incineration, gasification, or pyrolysis.
- Singapore's Tuas South Incineration Plant processes **3,000 tonnes per day**. 105 tonnes per hour, 35 barG at 370 °C. 0.17 barA. **80 MW**, 10.5kV **generator** voltage.
- Each ton of waste generates 500-600 kWh of electricity, at 6 cents per **kWh**

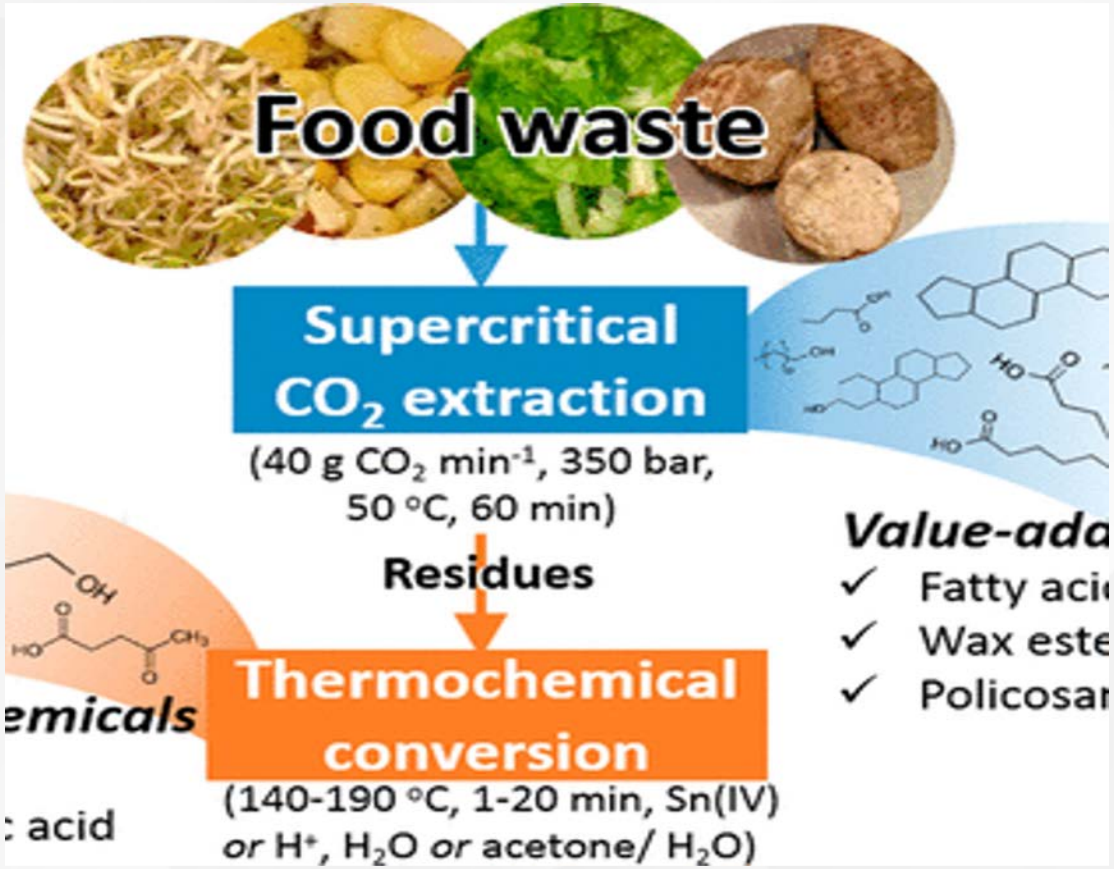
Waste to Hydrogen (W to H)



- Organic and plastic waste is used to produce hydrogen via pyrolysis, gasification, or anaerobic digestion.
- In Osaka, Japan, waste is converted into hydrogen to fuel buses and other hydrogen-powered vehicles.
- 60-80 kg of hydrogen can be produced from 1 ton of waste, contributing to 18% of global energy needs by 2050.

(Sharma et al., 2021)

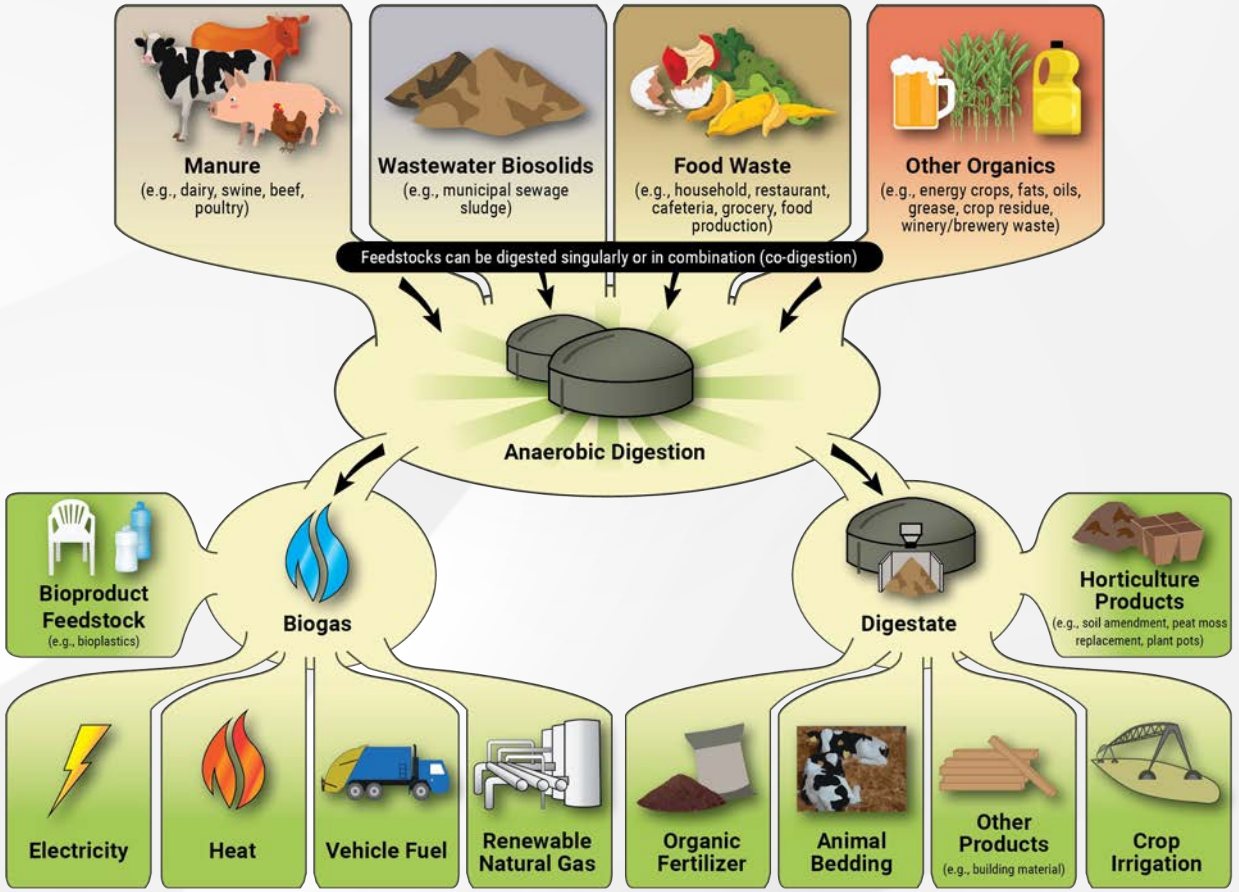
Waste to Chemicals and Enzymes



- Biological and chemical processes extract valuable chemicals and enzymes from waste, including food waste.
- Novozymes extracts 0.3 tons of enzymes per ton of food waste, used in food processing, biofuels, and detergents.
- Captures up to 50% of food waste's chemical potential, reducing raw material reliance and diverting waste from landfills.

Anaerobic Digestion (AD) W to AD

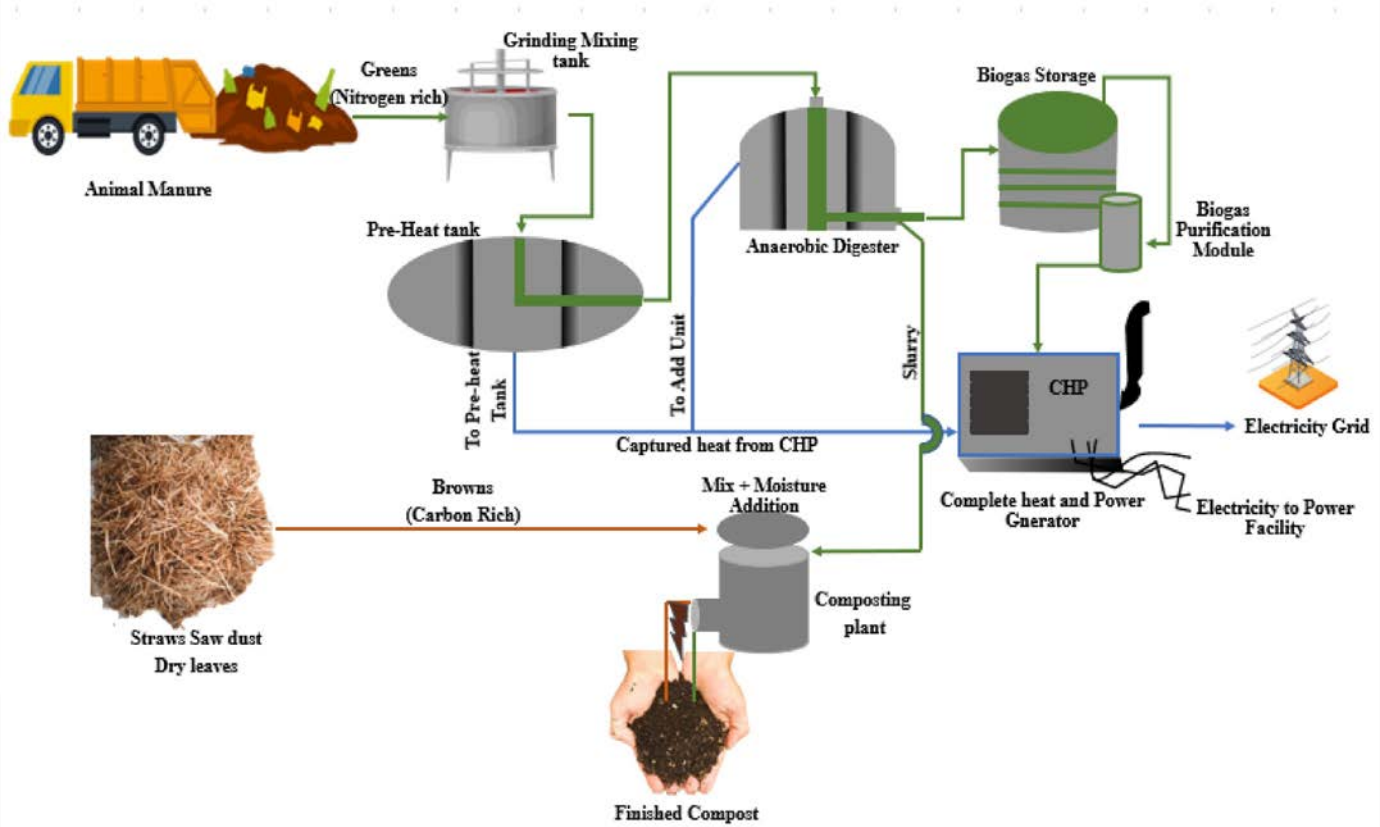
- Organic waste is broken down in anaerobic conditions, producing biogas for energy and digestate for fertilizers.
- Bioenergiepark Saerbeck processes 40,000 tons/year, generating 9.8 million cubic meters of biogas.
- Each ton of waste generates 100-150 cubic meters of biogas, producing 300-600 kWh of electricity.



Organic Waste Composting for Agricultural Soil Enhancement

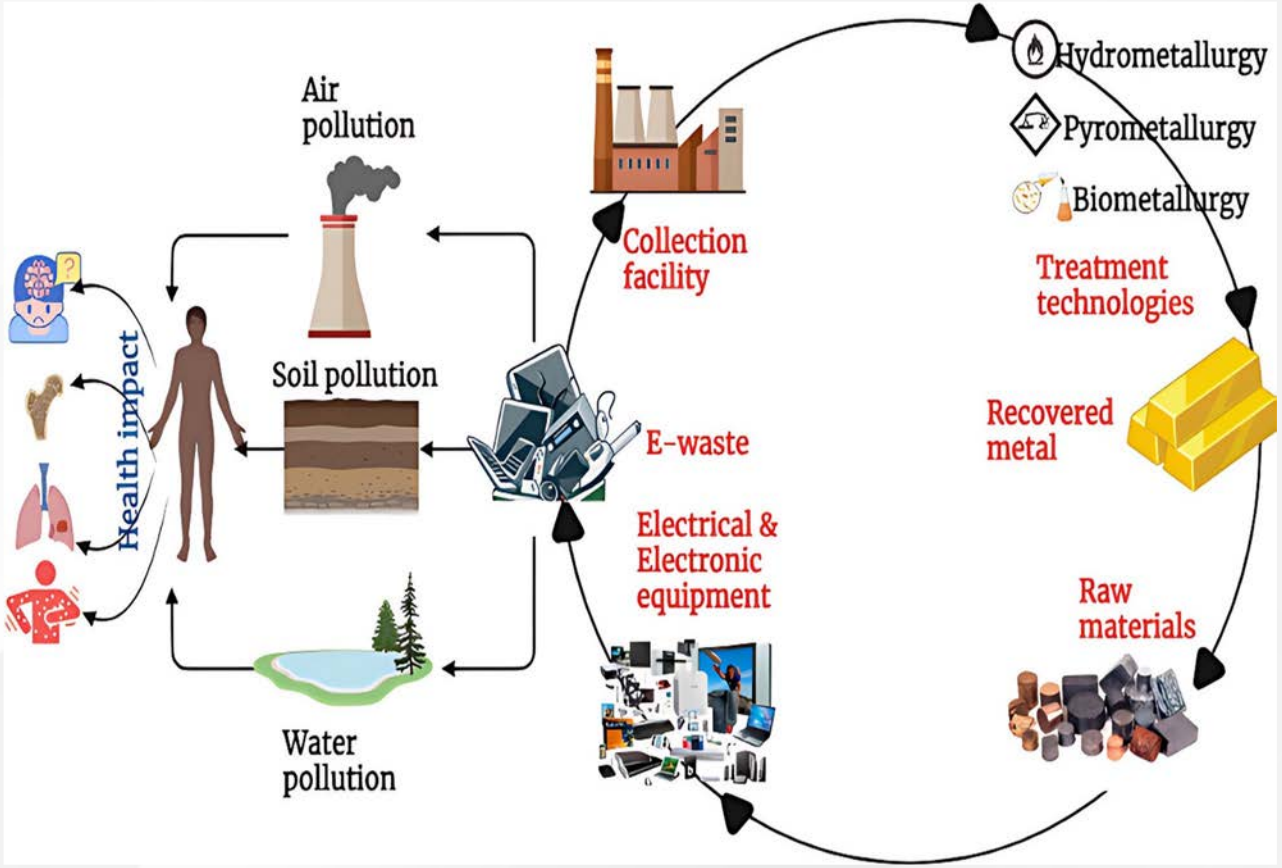
- Organic waste is biologically decomposed into nutrient-rich compost, enhancing soil health and fertility for agricultural use.
- The City of San Francisco processes 600 tons of organic waste daily, converting it into high-quality compost for agricultural applications.
- Each ton of organic waste produces 300-500 kg of compost, significantly improving soil fertility while diverting 50-70% of organic waste from landfills, reducing environmental impact.

Waqas et al. (2023)



E-Waste to Metal Recovery

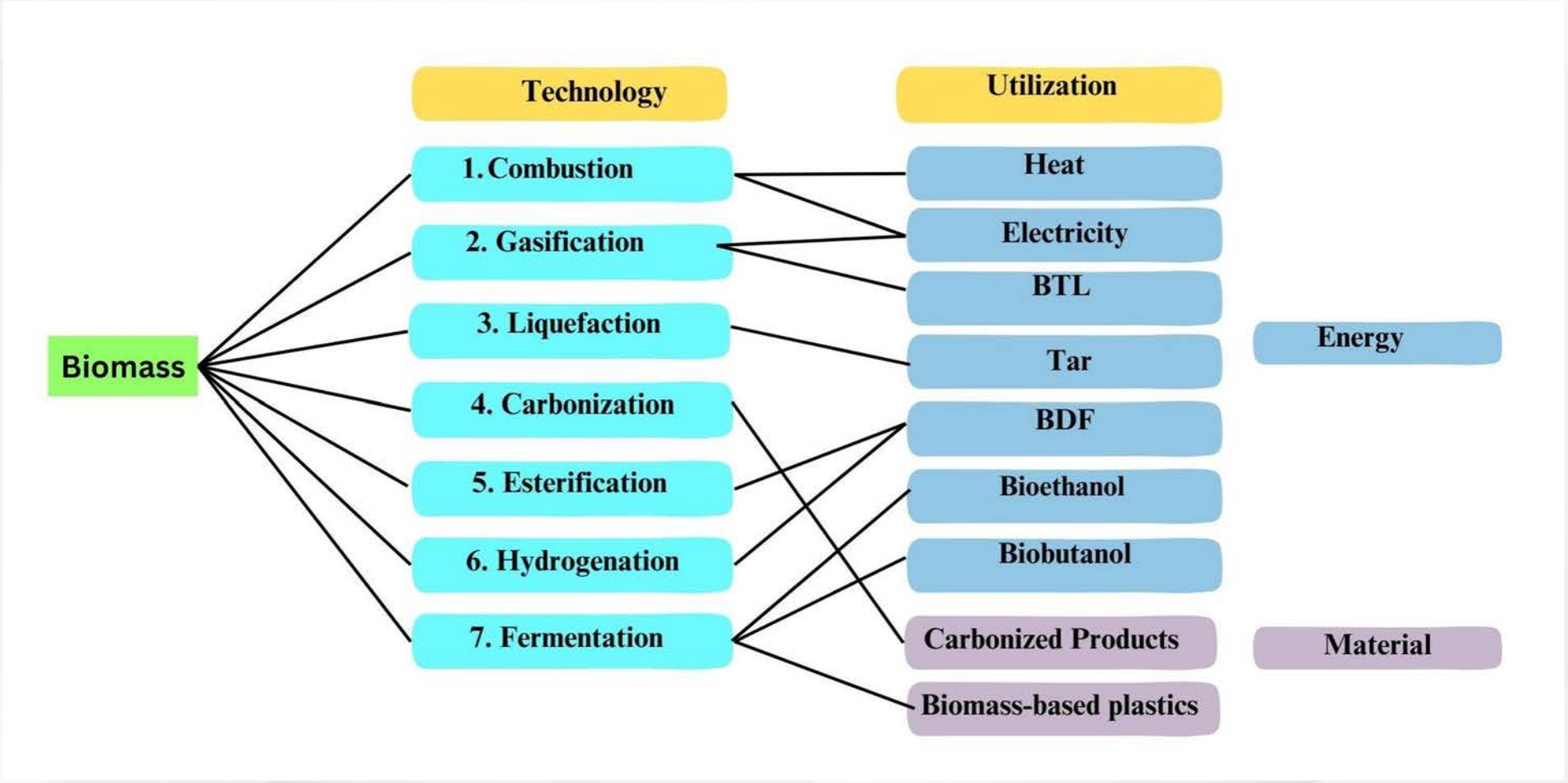
- Electronic waste (e-waste) is recycled to extract valuable metals such as gold, copper, silver, and palladium.
- Umicore, a Belgian company, processes 350,000 tons/year of e-waste, recovering 96 tons of gold, 350 tons of silver, and 50 tons of palladium annually.
- Each ton of e-waste contains up to 100 grams of gold and 300 grams of silver, providing a valuable secondary resource while reducing environmental pollution from discarded electronics.



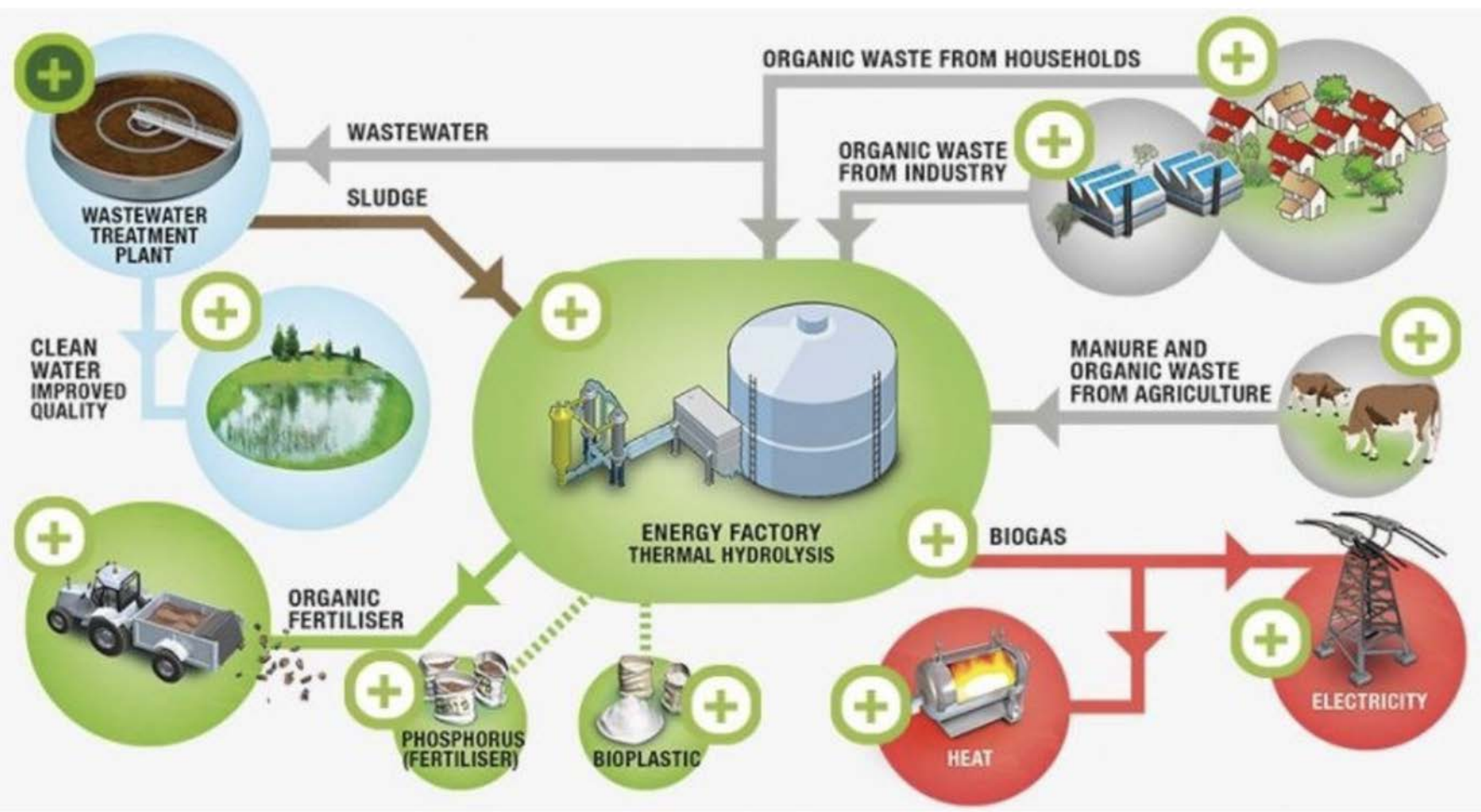
Global Initiatives

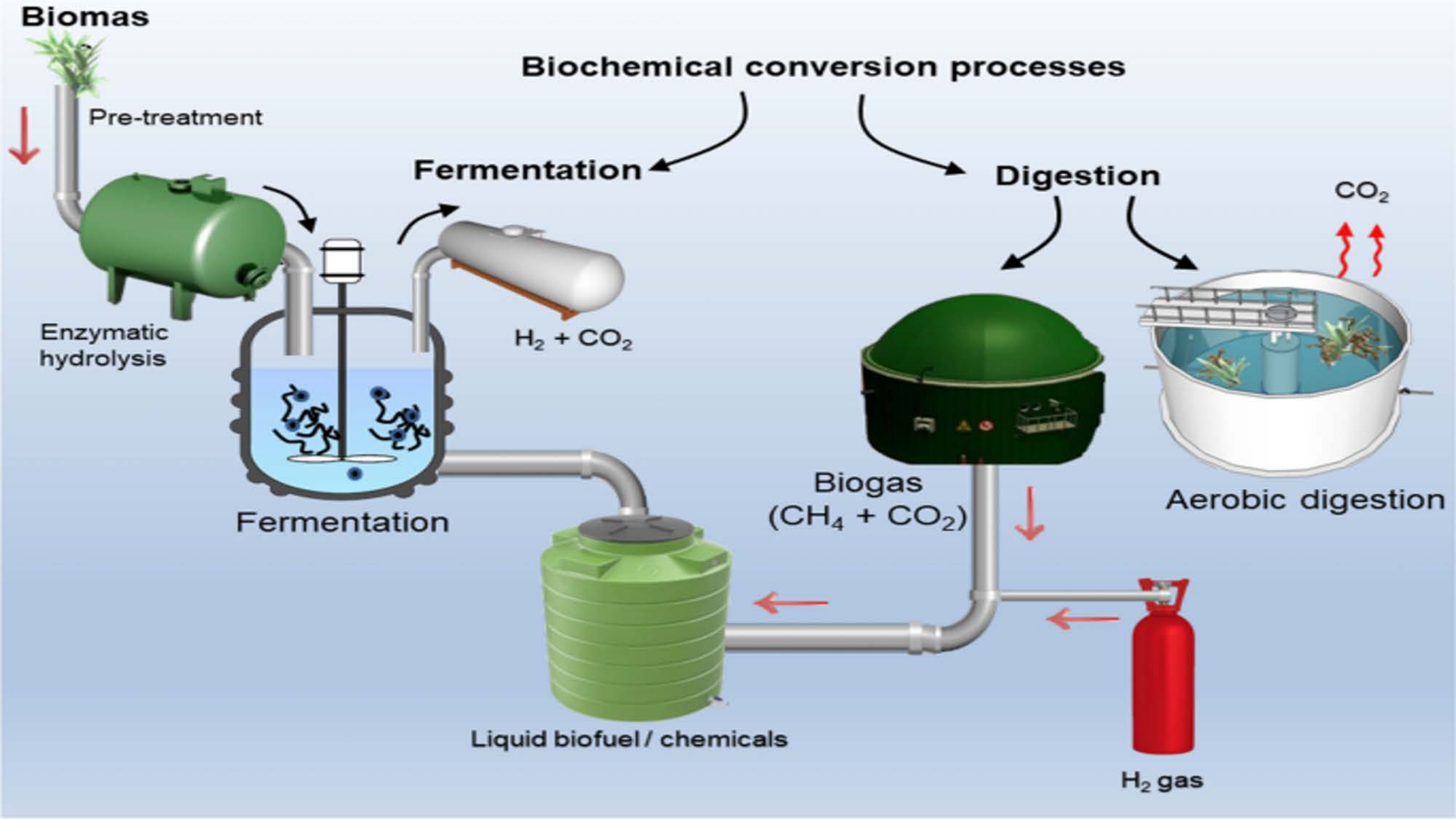
Focus Area	Details
Solid Waste Emissions	• If unaddressed, emissions could reach **2.6 billion tonnes of CO2-equivalent by 2050**. • Enhanced waste management practices can bolster city resilience against flooding.
Informal Recycling	• Properly organized recycling efforts can generate jobs, alleviate poverty, and reduce municipal costs. • Over **15 million** informal waste pickers face unsafe working conditions and lack social support.
What a Waste 2.0 Recommendations	• Key strategies include formalizing the role of waste pickers, strengthening recycling initiatives, and exploring new employment opportunities for these workers.

Biomass, Technology and Utilization



Billunds Biorefinery Process




Biomas
Biochemical conversion processes
Pre-treatment
Fermentation
Digestion
CO_2
Enzymatic hydrolysis
$H_2 + CO_2$
Fermentation
Biogas ($CH_4 + CO_2$)
Aerobic digestion
Liquid biofuel / chemicals
H_2 gas

Innovative Waste Management Solutions

Category	Innovation	Description
Smart Waste Collection	IoT Sensors	Monitor bin levels and optimize collection routes.
	Mobile Apps	Provide recycling options and collection schedules.
Advanced Recycling Technologies	Automated Sorting Systems	Use AI to efficiently sort recyclables.
	Chemical Recycling	Break down plastics for reuse in new products.
Waste-to-Energy Technologies	Anaerobic Digestion	Convert organic waste into biogas.
	Gasification	Turn materials into energy sources.
Composting Innovations	In-Vessel Composting	Faster, controlled organic waste decomposition.
	Bio-reactors	Efficient breakdown of organic materials.

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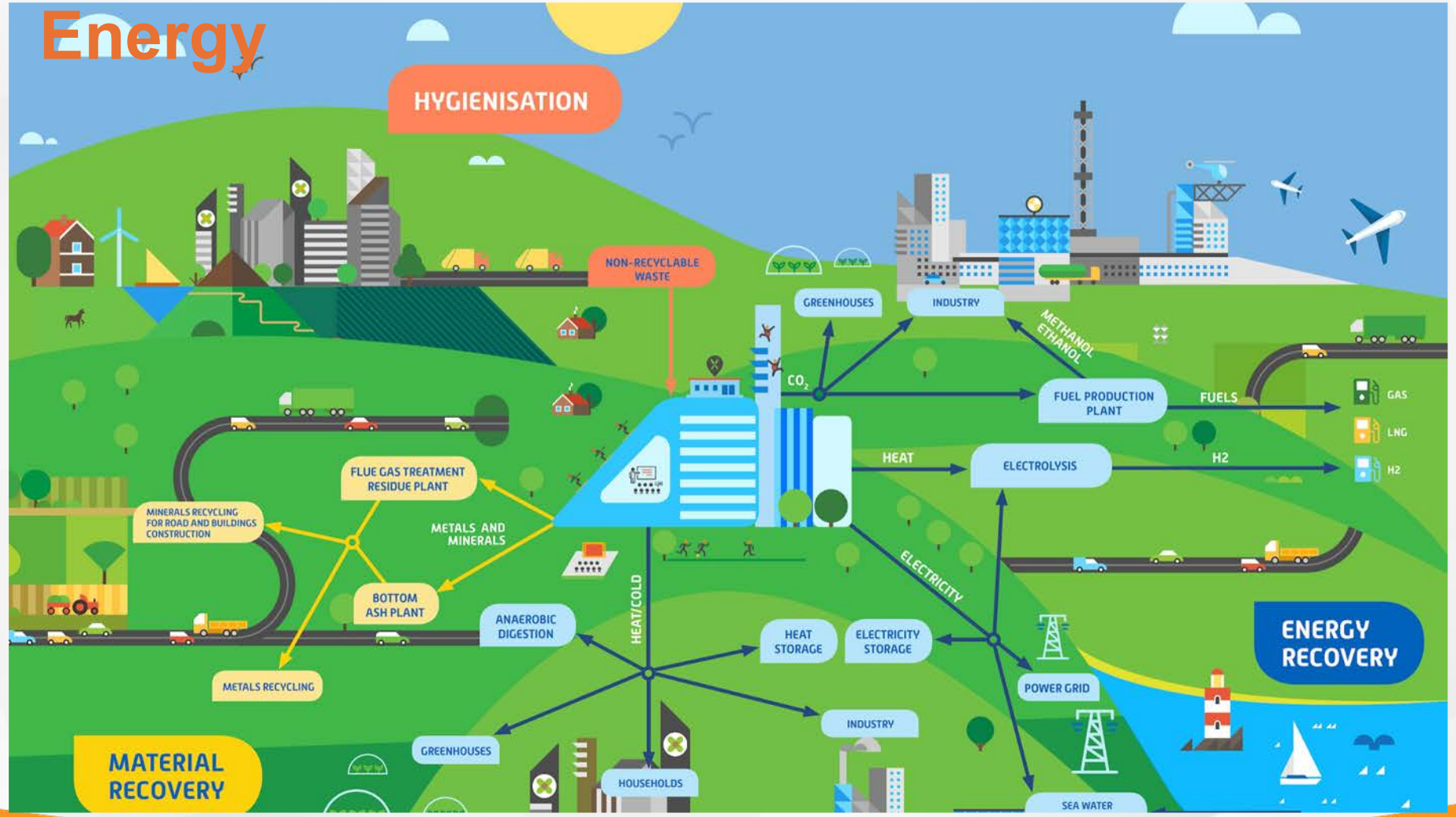
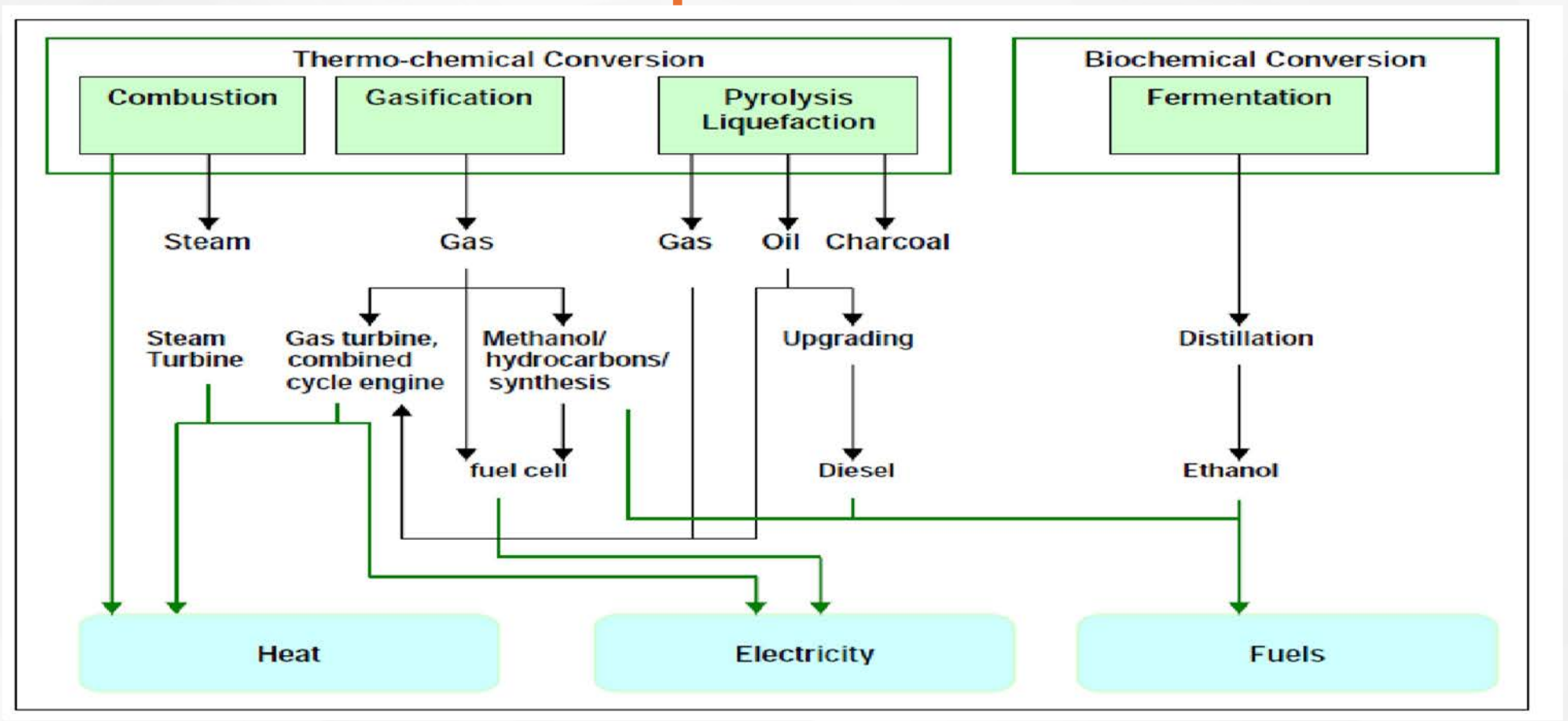
Trash to Treasure: Harnessing Waste-to-Energy



Thermo-Chemical Conversion and Biochemical Conversion process



Industrial Symbiosis

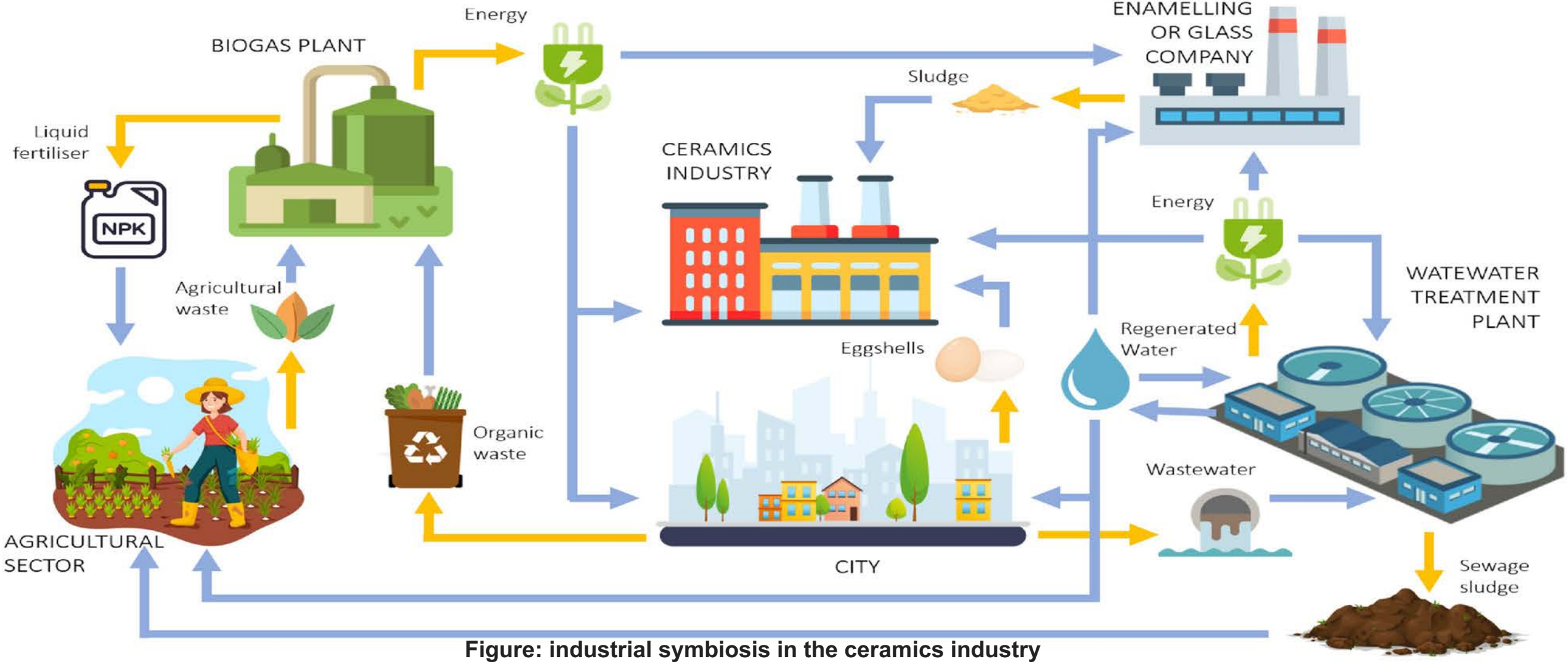
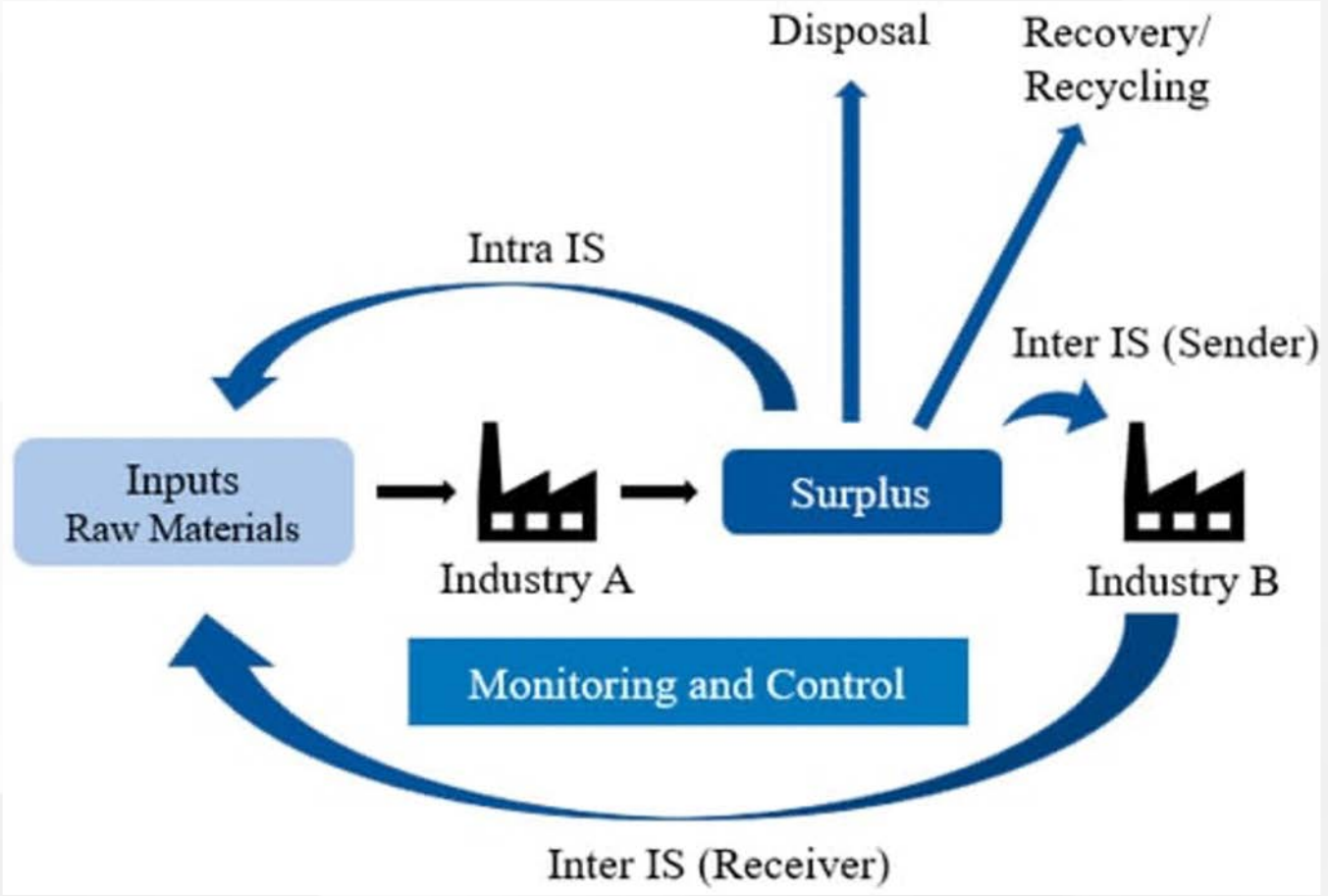


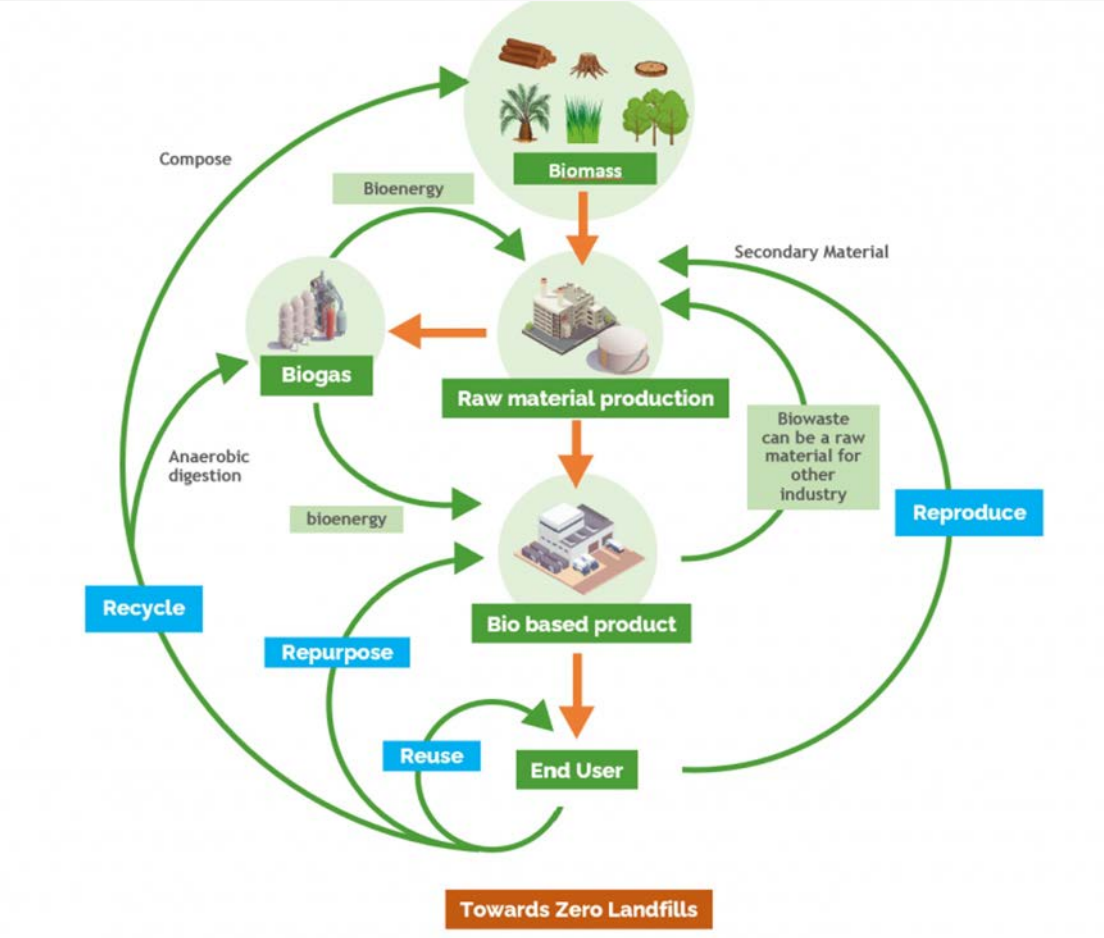
Figure: industrial symbiosis in the ceramics industry

Industrial Symbiosis Tool

•**Figure:** Materials and surplus flow scheme options. the potential material flows of Input Raw Materials and Surplus (wastes and by-products),



Circular Economy



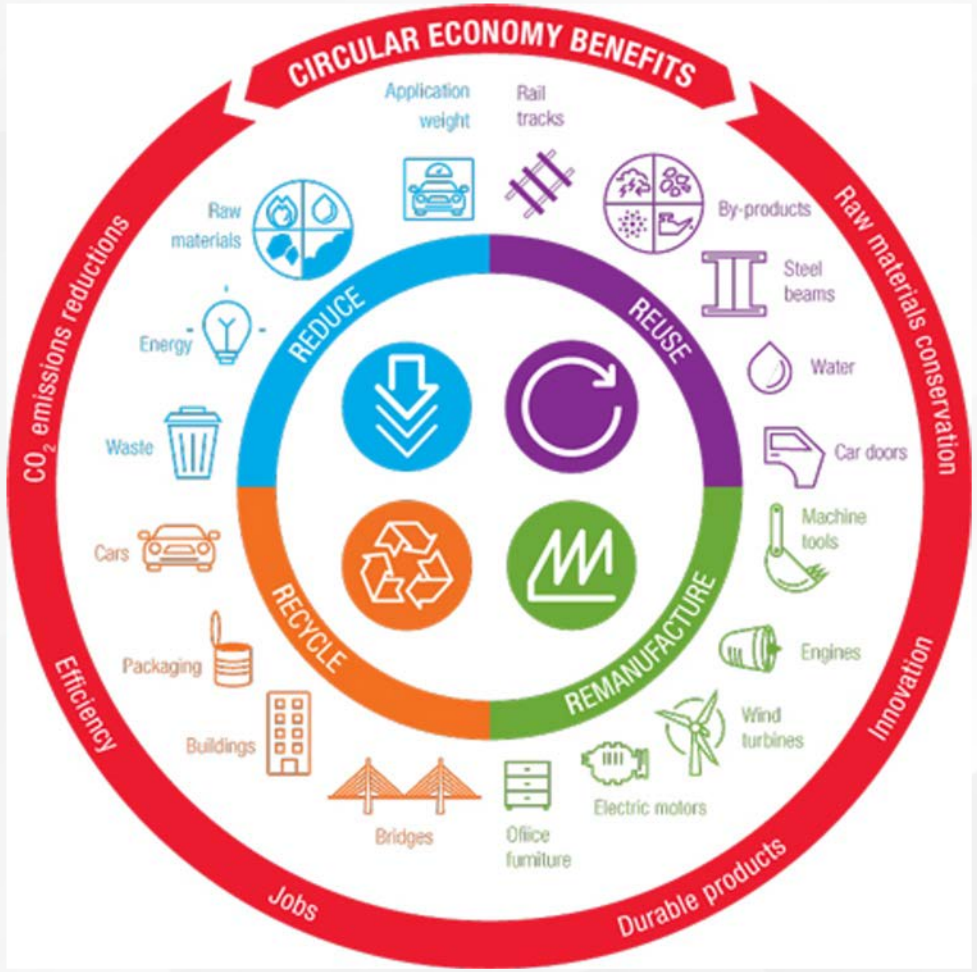
- Globally, the circular economy could reduce **45% of greenhouse gas emissions** from industrial sectors by 2050, if fully adopted
- In Malaysia, the government aims to achieve **40% recycling rate** by 2025 as part of its efforts to transition to a circular economy.
- **Government Policies (Numbers & Percentages)**:
- Malaysia's initiatives include **30% incentives** for green technology and sustainability projects under the Green Technology Financing Scheme.
- Fines for non-compliance with waste management regulations can go up to **RM 500,000** under the Environmental Quality Act.

Waste as a Resource in 3R

Waste is managed through reducing, reusing, and recycling materials to minimize environmental impact.

- **Reduce**: The IKEA climate footprint was estimated at 23.7 million tonnes CO2 eq in absolute terms. This is a 12% reduction compared to FY22 and 22% reduction compared
- **Reuse**: Habitat for Humanity ReStores repurpose building materials, reducing demand for new resources.
- **Recycle**: Germany recycles 65-70% of its waste, making it a global leader in recycling efficiency. Recycling 1 ton of plastic saves 2,500 liters of oil, and 1 ton of paper saves 17 trees.

Circular Economy Concept



1.Transforming Waste into Resources: Converts 100% of waste into valuable materials.
2.Reducing Raw Material Extraction: Minimizes raw material demand by up to 50%.
3.Focus on Recycling, Reusing, and Composting:

1. **Recycling**: Recycles 75-90% of plastics, metals, and glass.
2. **Reusing**: Extends product life by 20-30%.
3. **Composting**: Reduces organic waste by 40-60%.

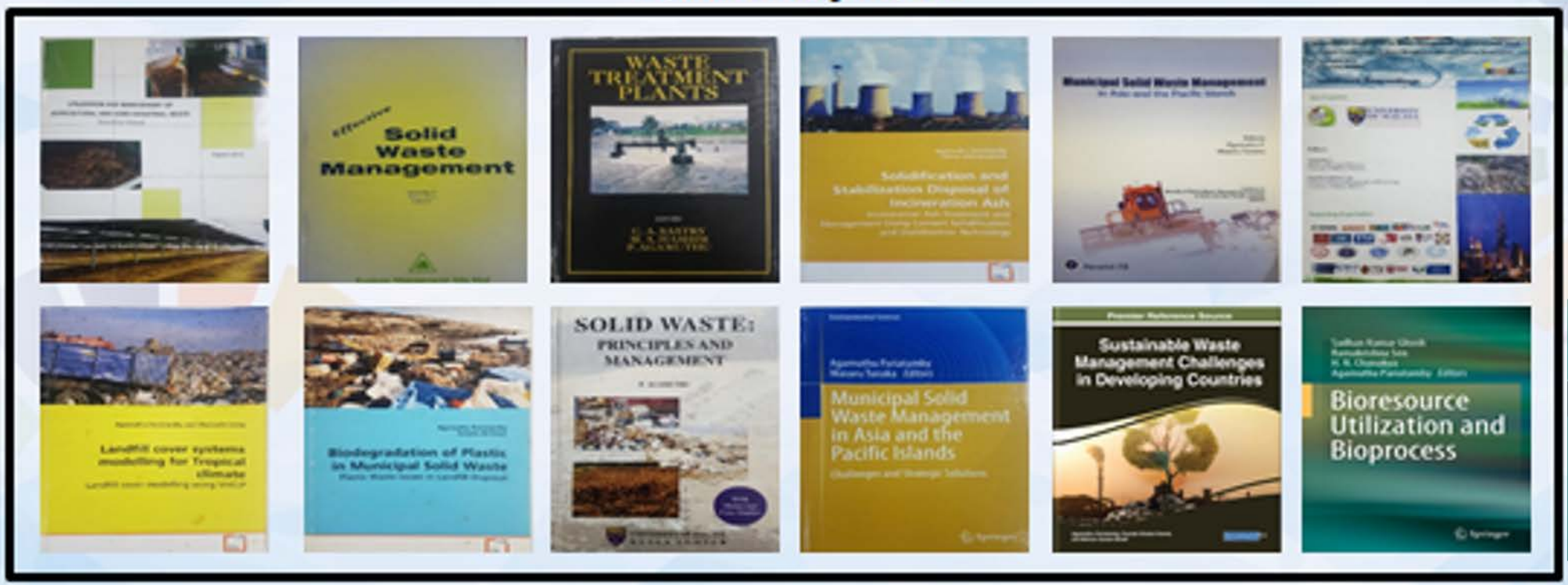
Value Chain

1.Turning Food Waste into Compost: Converts 70-80% of food waste into organic fertilizer.
2.Recycling Plastics, Metals, and Glass: Reclaims 85-95% of materials, cutting raw material needs by 30-40%.

Conclusion

"From Waste to Worth" illustrates how innovative waste management can reclaim up to **90%** of discarded materials, turning waste into resources. By focusing on recycling, reusing, and composting, we can reduce raw material use by up to **50%** and create a more sustainable future that benefits both the environment and society.

Some of My Books



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