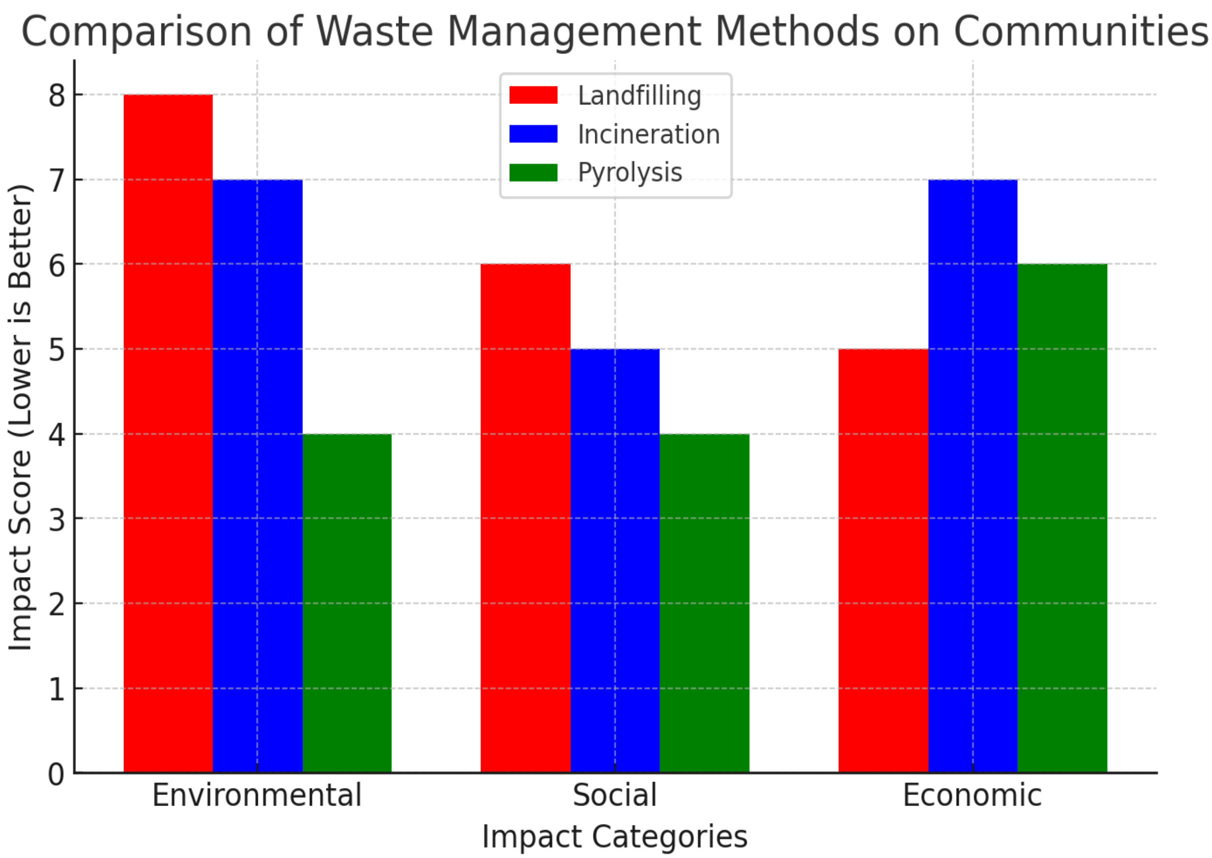
White Paper on Waste Mitigation Options: Landfilling, WtE Incineration & WtF Pyrolysis – Environmental, Social and Economic Impact

Ranking (Best → Worst)

The following is a detailed ranking and comparison of average emissions and community impacts from **waste landfilling, waste incineration, and waste pyrolysis** in terms of key pollutants and values. The values are approximate and based on multiple studies, however details may vary depending on waste composition, technology, and operating conditions deployed.

1. **Pyrolysis** (Lowest emissions, but still dependent on technology and residue handling)
2. **Landfilling** (Methane capture can improve ranking, but long-term emissions remain high)
3. **Incineration** (Highest emissions, but energy recovery can partially offset its impact)



The bar chart above is a comparison of the impact of **landfilling, incineration, and pyrolysis** on communities across **environmental, social, and economic** factors. Lower scores indicate better performance.

The **Environmental, Social, and Economic** impact rankings for each waste disposal method:

1. Landfilling

- **Environmental Impact: 8/10 (High impact, worst overall)**
  - Methane (CH_4) emissions contribute heavily to climate change.
  - Leachate contamination affects groundwater and soil.
  - Land use issues and long-term waste degradation concerns.
- **Social Impact: 6/10 (Moderate impact)**
  - Landfills create unpleasant odors, pests, and potential health hazards for nearby communities.
  - Often disproportionately placed in lower-income areas.
  - Public opposition due to stigma and environmental justice concerns.
- **Economic Impact: 5/10 (Lower cost but long-term burdens)**
  - Initial setup is relatively cheap.
  - Requires long-term maintenance and remediation costs.
  - Loss of valuable land that could be used for development.

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2. Incineration

- **Environmental Impact: 7/10 (Moderate impact, but still significant)**
  - Reduces waste volume but releases CO_2, NO_x, SO_x, dioxins, and heavy metals.
  - Requires advanced filtration and emissions control to minimize harm.
  - Energy recovery from waste can offset some negative environmental effects.
- **Social Impact: 5/10 (Moderate impact, better than landfills)**
  - Reduces waste accumulation in communities but generates air pollution concerns.
  - Often placed near industrial zones, still raising equity concerns.
  - Potential for job creation in waste-to-energy sectors.
- **Economic Impact: 7/10 (High cost but energy benefits)**
  - High capital investment in infrastructure and technology.
  - Can generate revenue from energy production.
  - Expensive to maintain emission control systems.

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3. Pyrolysis

- **Environmental Impact: 4/10 (Lowest impact, best for sustainability)**
  - Produces biochar, bio-oil, and syngas instead of toxic emissions.
  - Lower carbon footprint than incineration and landfilling.
  - Requires proper handling of byproducts to avoid contamination.
- **Social Impact: 4/10 (Lowest impact, most acceptable)**
  - Minimal air pollution and nuisance compared to incineration.
  - Can be integrated into circular economy models (waste-to-fuel).
  - Less opposition from communities compared to landfills and incinerators.
- **Economic Impact: 6/10 (Moderate cost, but with potential gains)**
  - Requires high initial investment in advanced technology.
  - Can generate marketable byproducts like biofuels, reducing reliance on fossil fuels.
  - Still developing commercially, so costs will reduce with wider adoption.

Final Rankings (Best → Worst)

1. **Environmental:** Pyrolysis → Incineration → Landfilling
2. **Social:** Pyrolysis → Incineration → Landfilling
3. **Economic:** Landfilling → Pyrolysis = Incineration

Pyrolysis is the best option environmentally and socially. Landfilling is the least expensive regarding initial costs but carries long-term economic burdens and risk. Incineration can have a strong economic advantage due to energy recovery, as can pyrolysis due to its production and sale of valuable transportation fuels. Landfilling remains the least favorable overall in all aspects.

Pollutant (g/kg of waste treated)	Landfilling	Incineration	Pyrolysis	Best to Worst (Ranking)
CO_2 (Carbon Dioxide)	400–600 (indirect from methane)	800–1200	200–500 (can be lower if Closed-Loop Pyrolysis)	Pyrolysis → Landfilling → Incineration
CH_4 (Methane)	10–40	~0	~0	Pyrolysis = Incineration → Landfilling
CO (Carbon Monoxide)	Negligible	2–5	0.5–2	Landfilling → Pyrolysis → Incineration
NO_x (Nitrogen Oxides)	Negligible	1–3	0.2–1	Pyrolysis → Landfilling → Incineration
SO_x (Sulfur Oxides)	Negligible	0.5–3	0.1–0.5	Pyrolysis → Landfilling → Incineration
Dioxins & Furans	Negligible	0.01–5 ng TEQ/kg	0.001–0.1 ng TEQ/kg	Pyrolysis → Landfilling → Incineration
PM (Particulate Matter)	Negligible	0.5–5	0.1–2	Pyrolysis → Landfilling → Incineration
Heavy Metals (e.g., Pb, Cd, Hg)	Low	High	Low	Pyrolysis = Landfilling → Incineration
VOC (Volatile Organic Compounds)	5–50	0.1–5	0.1–1	Pyrolysis → Incineration → Landfilling
PFAS	High	Moderate	Negligible	Pyrolysis → Incineration → Landfilling
Land Impact (Loss/ Contamination)	High	Low	Low	Pyrolysis = Incineration → Landfilling