

U.S. DEPARTMENT OF
ENERGY

Office of
ENERGY EFFICIENCY &
RENEWABLE ENERGY

Bioenergy, Sustainability, and Waste Resources

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Bioenergy Sustainability is a Key Focus Area

SUSTAINABILITY



Greenhouse gas emissions
Water quality and quantity
Soil quality
Air quality

Economic growth and resilience
Affordability
Energy security
Process efficiency

Jobs and workforce development
Health and well being
Food security
Social acceptability

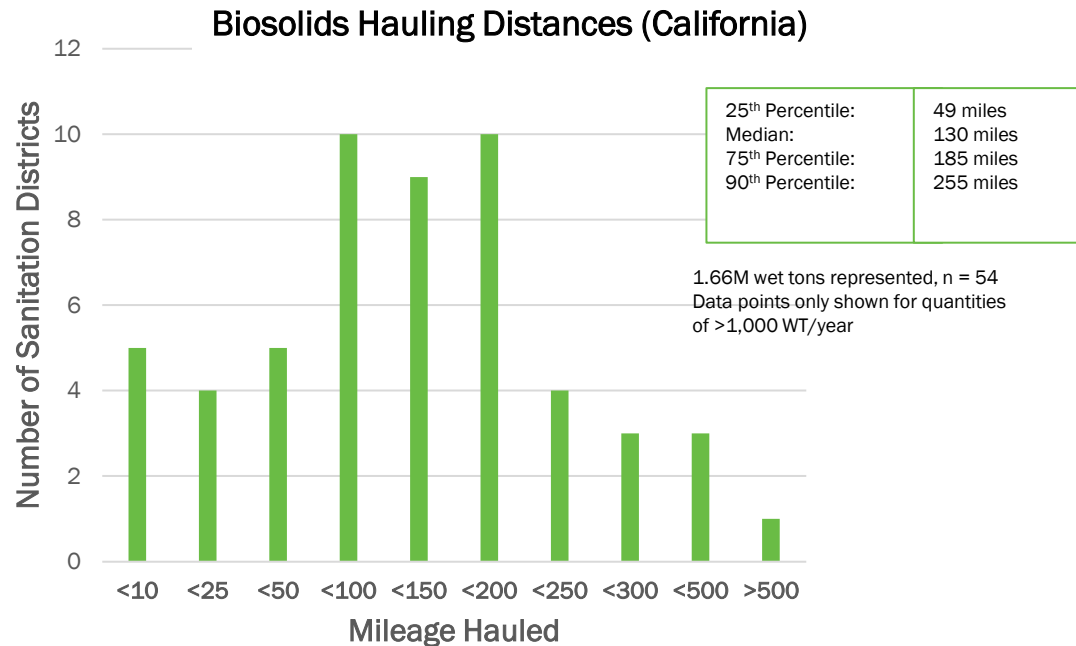
Waste Resources Offer New Feedstocks And Sustainability Challenges



Economic, Environmental, and Social Sustainability Implications for Organic Waste



Economic Sustainability of Organic Waste Processing



Sources: BACWA 2016 Biosolids Trends Survey
2016 SCAP Biosolids Trends Survey

- The cost of managing wastes is increasing.
- Organics bans in landfills have led to increases in how far wastes have to be transported for disposal or processing

Municipal Sludge Management Costs ²



Across categories like beneficial reuse, incineration, and landfilling, average sludge management costs have increased by 37% since 2018 due to requirements to mitigate PFAS

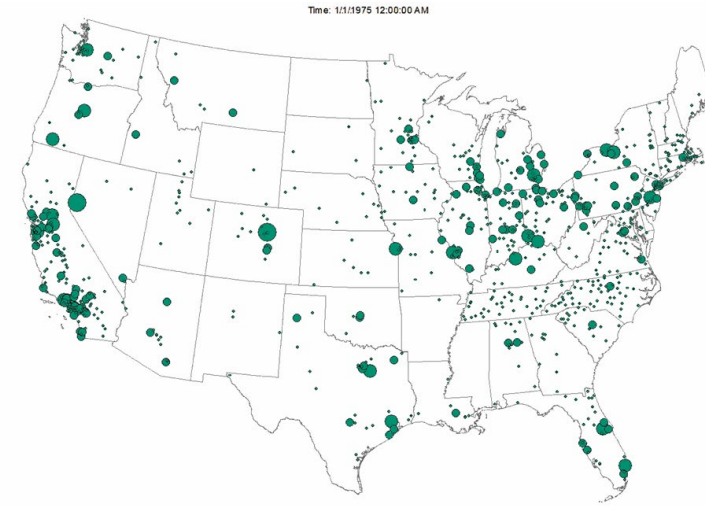
¹ <https://legislature.vermont.gov/assets/Legislative-Reports/2016-DEC-Sludge-and-Septage-Report-1-16-2016.pdf>

² <https://www.wef.org/globalassets/assets-wef/3---resources/topics/a-n/biosolids/technical-resources/cost-analysis-of-pfas-on-biosolids---final.pdf>

³ <https://www.wastetodaymagazine.com/article/eref-releases-analysis-national-msw-landfill-tipping-fees/#:~:text=The%20average%20MSW%20landfill%20tip,states%20without%20active%20WTE%20facilities.>

Environmental Sustainability of Organic Waste Processing

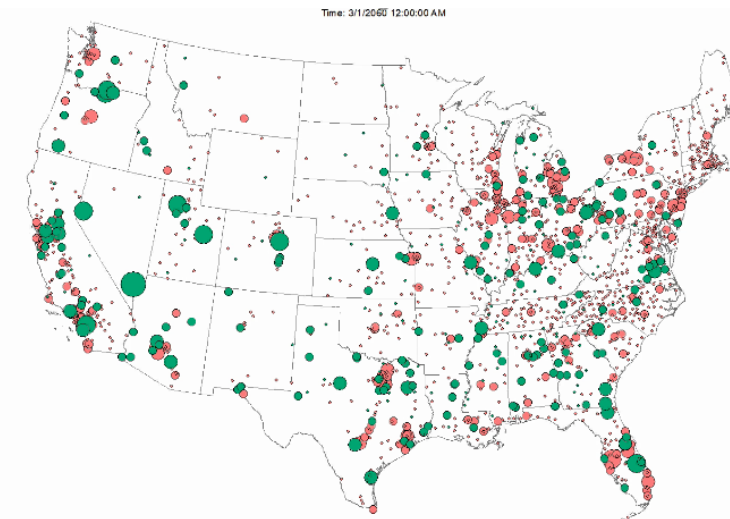
- Landfills are the 3rd largest source of CH₄ emissions nationwide, (114 MMT CO₂e/yr)
- Between 2020 and 2060, the number of available landfills will have decreased by 69%
- Organic waste landfill bans have been implemented in >7 states, many communities have also implemented targets or zero waste goals¹



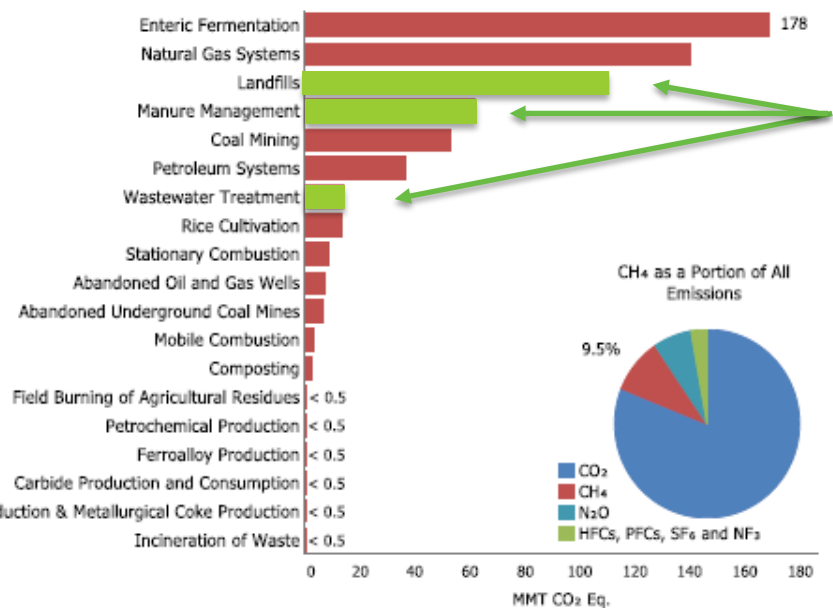
Landfill Availability 1975



- Open Landfill
- Closed (full) Landfill



Landfill Availability 2060

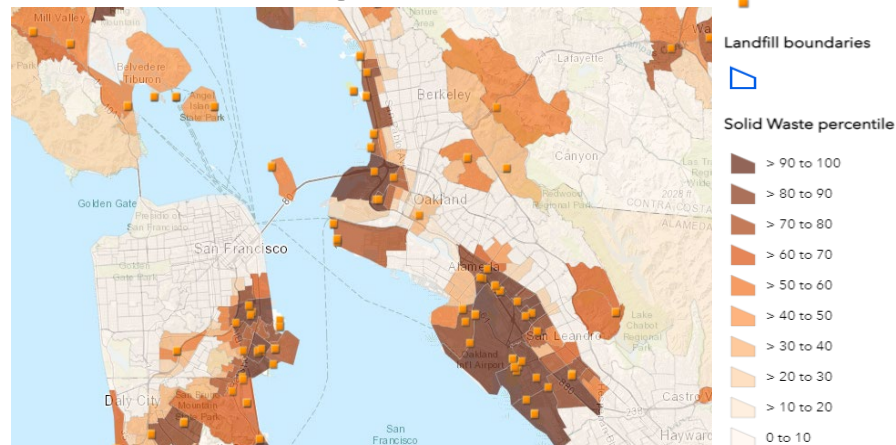


>230 MMT/yr GHG emissions (CH₄, NO_x, CO₂)

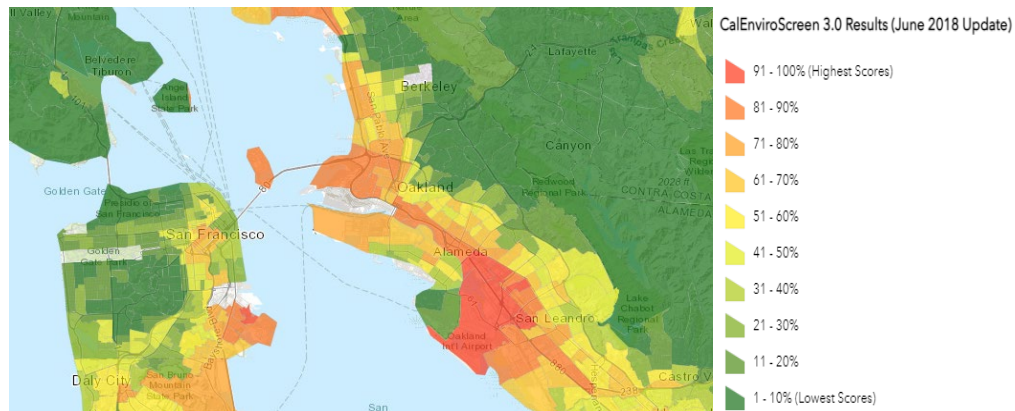
¹<https://www.sciencedirect.com/science/article/abs/pii/S1364032119306331?dgcid=author>

Social Sustainability of Organic Waste Processing

Solid Waste Handling Facilities²



Overall CalEnviroScore²



- Organic waste is generated everywhere
- Siting of waste handling infrastructure is disproportionately in disadvantaged communities³
- Environmental impacts can be numerous from waste processing facilities: odor, noise, infectious disease vectors, litter, particulate emissions⁴

Environmental justice is the fair treatment and meaningful involvement of all people, regardless of race, color, national origin, or income, with respect to the development, implementation, and enforcement of environmental laws, regulations, and policies.

¹ <https://dsl.richmond.edu/panorama/redlining/#loc=5/39.1/-94.58>

² <https://oehha.ca.gov/calenviroscreen/report/calenviroscreen-30>

³ Paul Mohai and Robin Saha 2015 *Environ. Res. Lett.* 10 115008

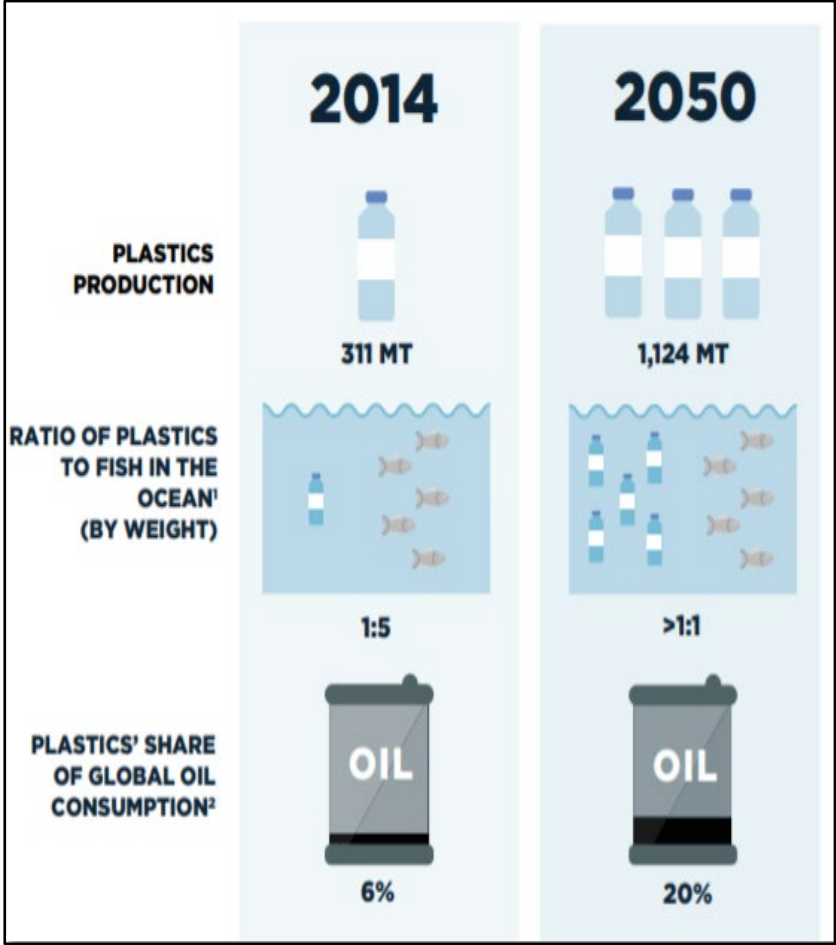
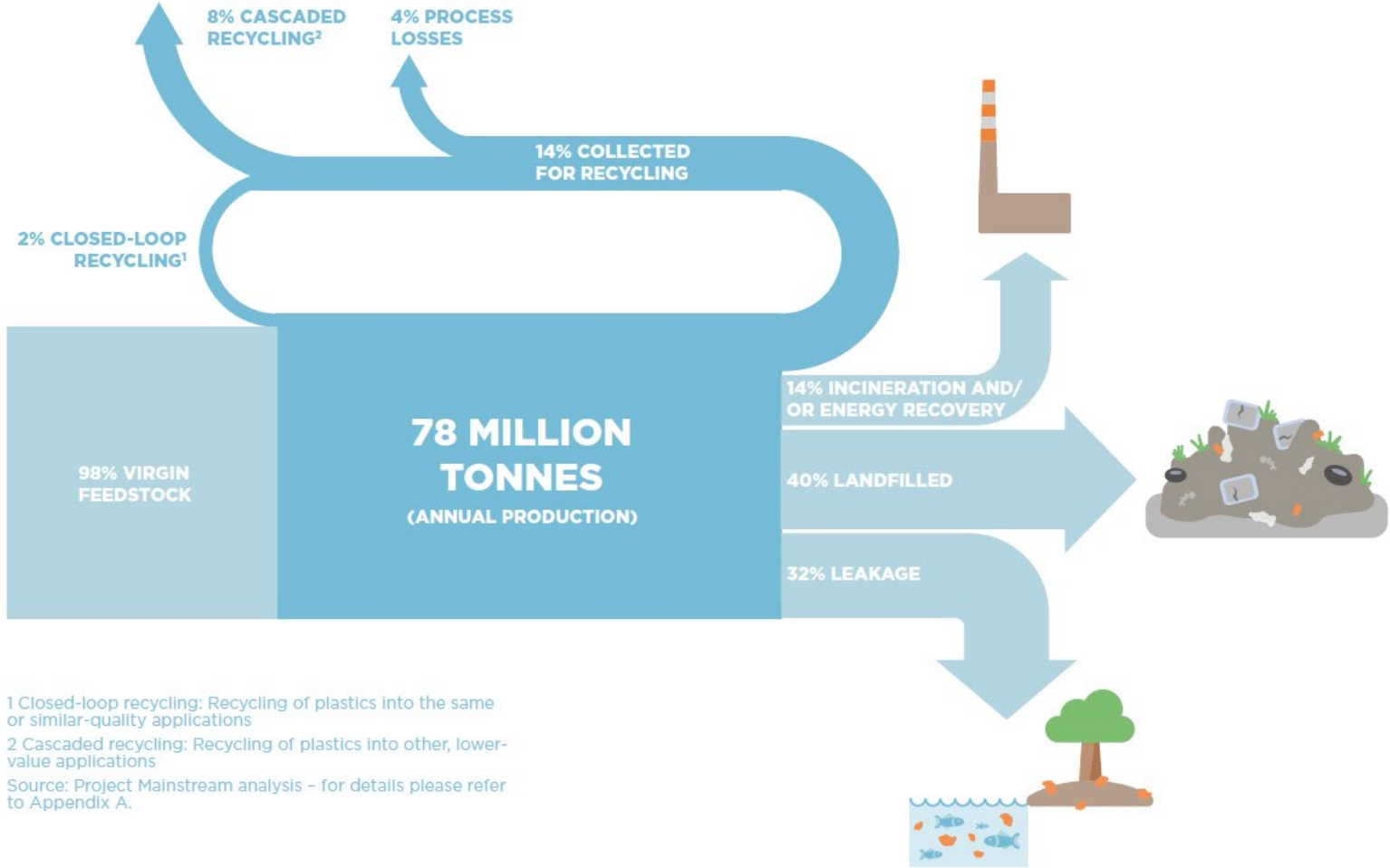
⁴ Krystosik A, Njoroge G, Odhiambo L, Forsyth JE, Mutuku F and LaBeaud AD (2020) Solid Wastes Provide Breeding Sites, Burrows, and Food for Biological Disease Vectors, and Urban Zoonotic Reservoirs: A Call to Action for Solutions-Based Research. *Front. Public Health* 7:405. doi: 10.3389/fpubh.2019.00405

Plastic Waste Case Study



Plastic Waste Is an Economic, Environmental, and Social Sustainability Problem

FIGURE 4: GLOBAL FLOWS OF PLASTIC PACKAGING MATERIALS IN 2013



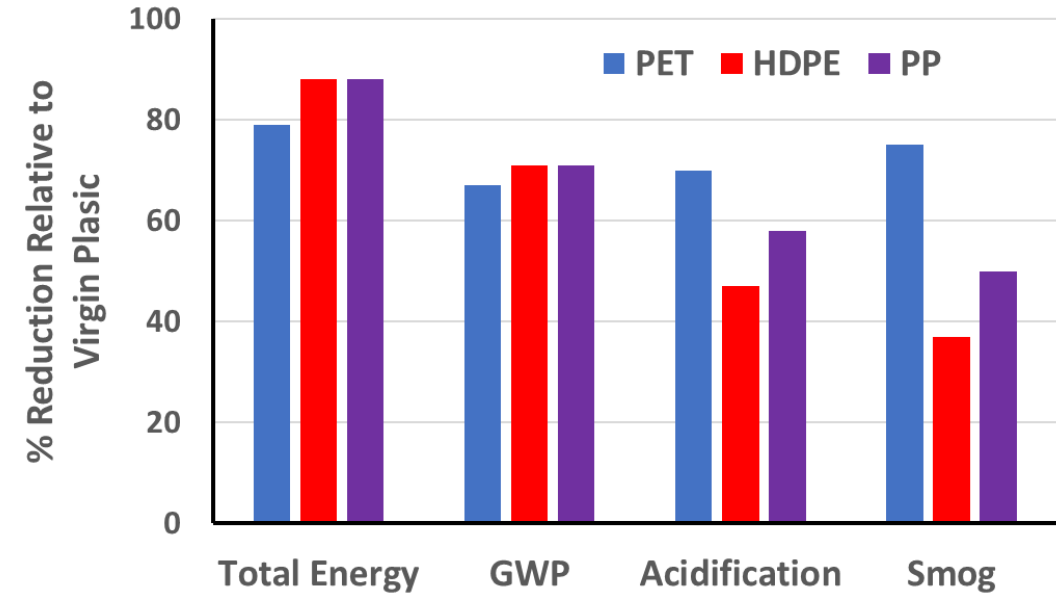
¹Geyer et al. Science Advances 2017
²Zheng and Suh. Nature Climate Change 2019
³Jambeck et al. Science 2015; Ellen MacArthur Foundation

Why Not Stop Using Plastic? Sustainability Is Complicated...



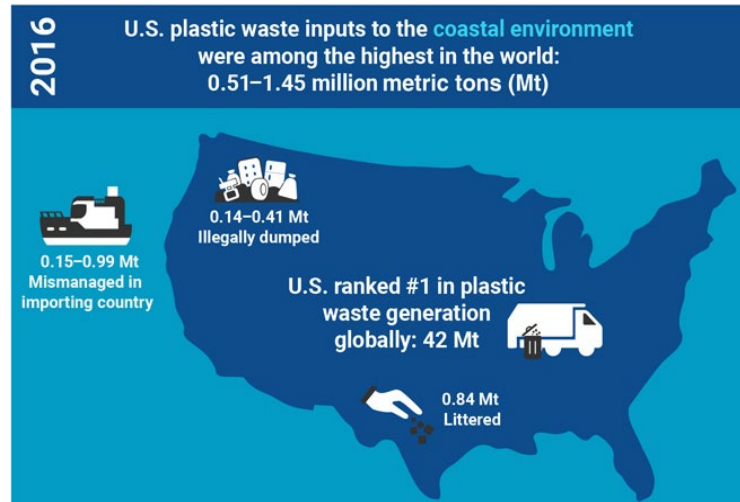
- Plastics have much lower GWP compared to next-best substitutes^{1,2}
- Plastics have large benefits in preventing food spoilage & other positive climate effects

1. Kimmel et al. *Environmental Studies* 2014, 6.
2. Trenor et al. *ACS Macro Lett.* 2020, 9, 1376–1390
3. Virgin vs Recycled Plastic LCA White Paper APR 2020



- Recycling plastic has large GHG impacts (>60% reductions)³
- Low recycling rates limit impact
- Current mechanical recycling often leads to down-cycling vs closed-loop
- New technologies have the potential for upcycling and same-cycling while improving on energy benefits

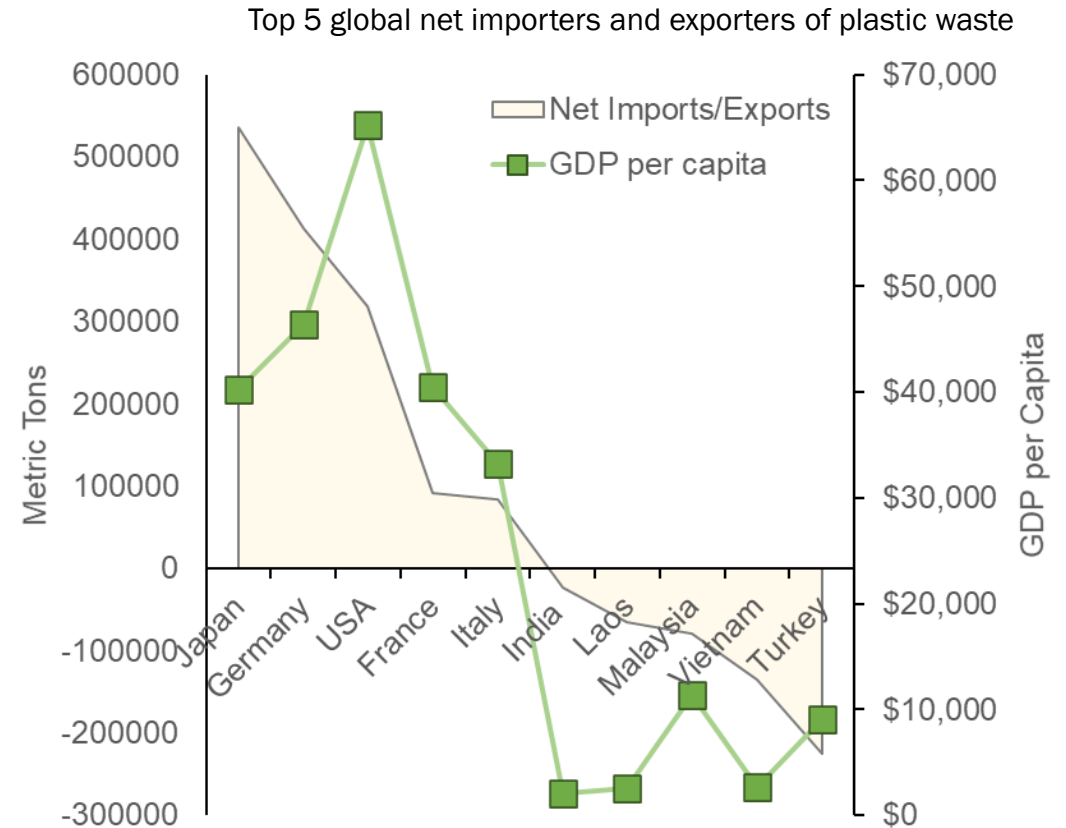
Environmental Justice Issues with Plastic Waste



The US generated the largest amount of plastic waste of any country in 2016, and is one of the biggest coastal polluters¹

¹Lavendar Law et al., Science Advances. 2020

²UN Comtrade Program and World Bank. 2019



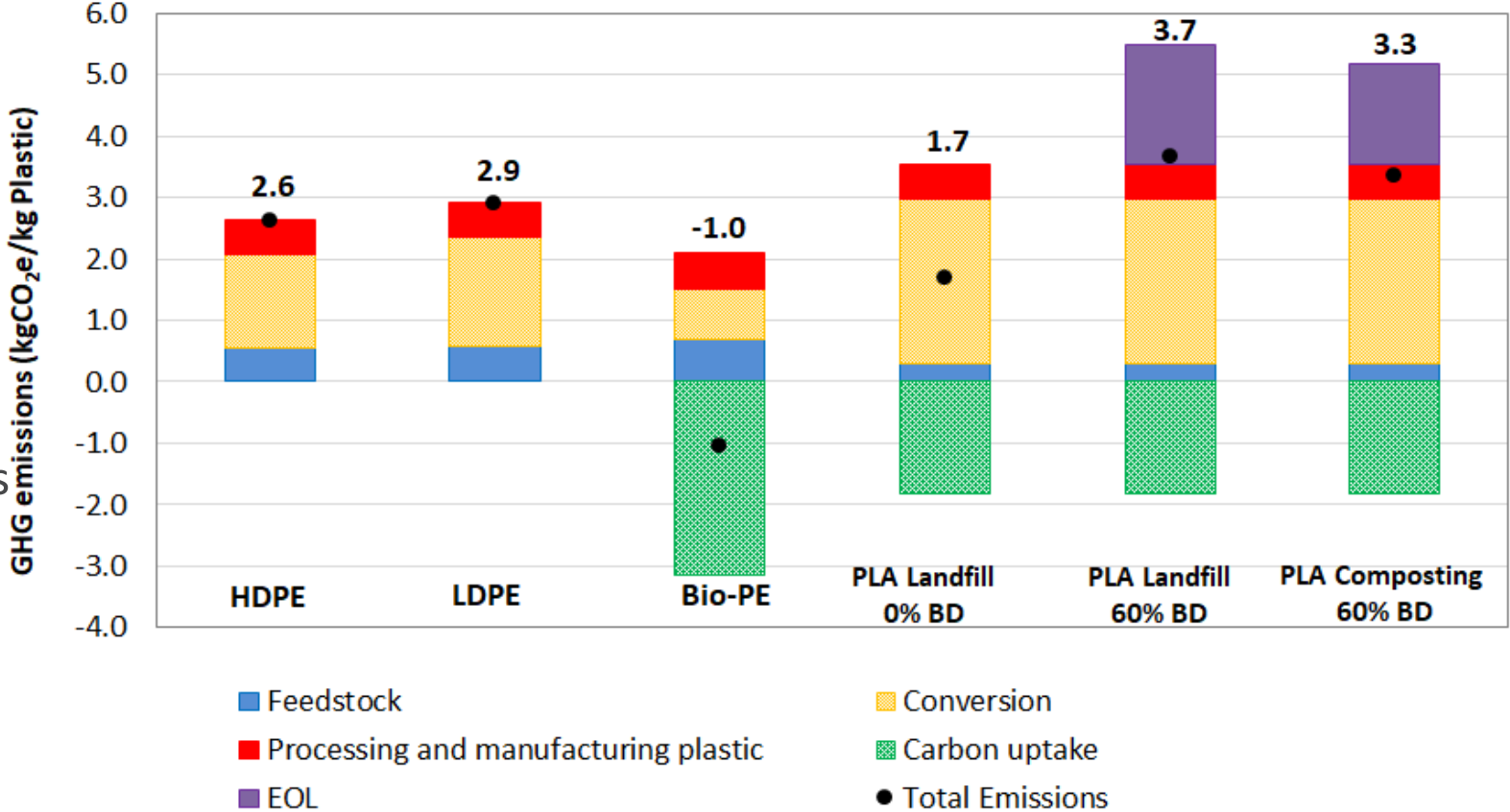
US formerly claimed 25% plastic recycling, but vast majority was exports.

Rich countries disproportionately export plastic waste to poor countries²

Basel Convention seeks to reduce waste export

Mitigating Sustainability Concerns With Plastics Is Complex

- Bio-PE can offer lower GHG emissions than the fossil-based counterparts
- Biodegradability can greatly influence GHG emissions of bioplastics designed to degrade
- Landfill and composting conditions of PLA determine biodegradability rates.
- Tradeoffs between landfilling and GHG emissions reductions



Benavides PT, Lee U, Zare-Mehrjerdi O. 2020. Life Cycle Greenhouse Gas Emissions and Energy Use of Polylactic Acid, Bio-Derived Polyethylene, and Fossil-Derived Polyethylene.' J of Cleaner Production. <https://doi.org/10.1016/j.jclepro.2020.124010>

Thank You!

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