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The **G**reenhouse Gas and **A**ir Pollution **In**teractions and **S**ynergies (GAINS) model:

Municipal solid waste

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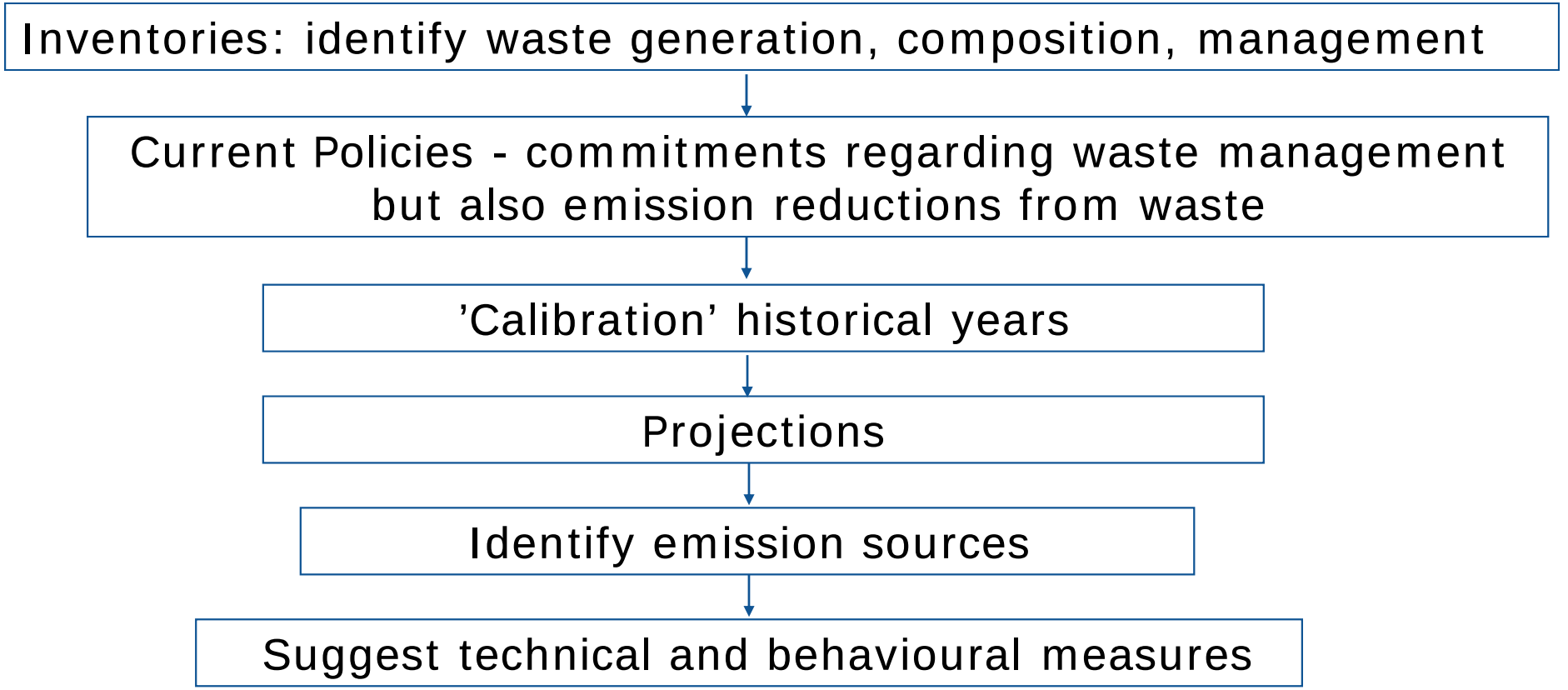
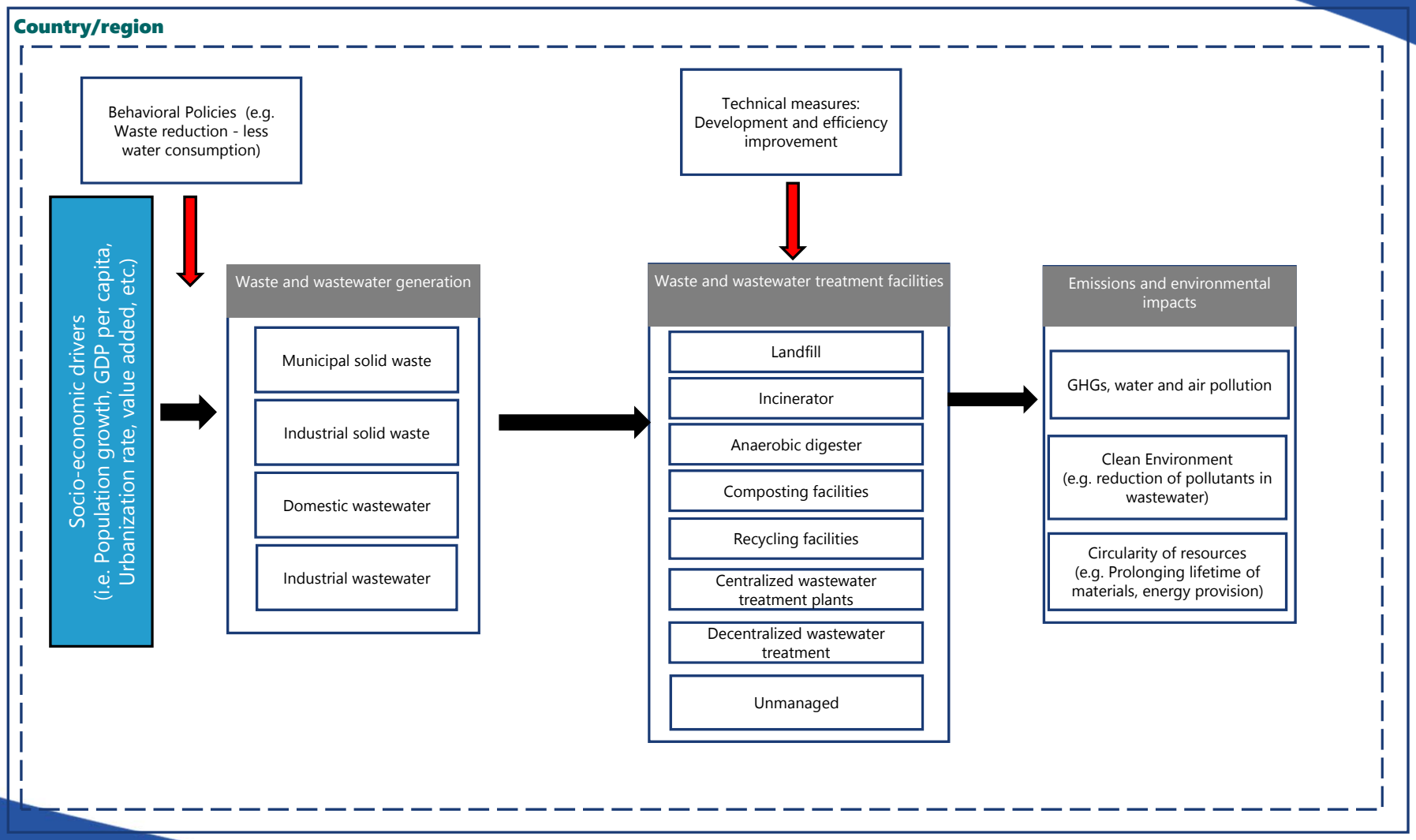
April 2021

Data Sources



Waste and wastewater sector in GAINS



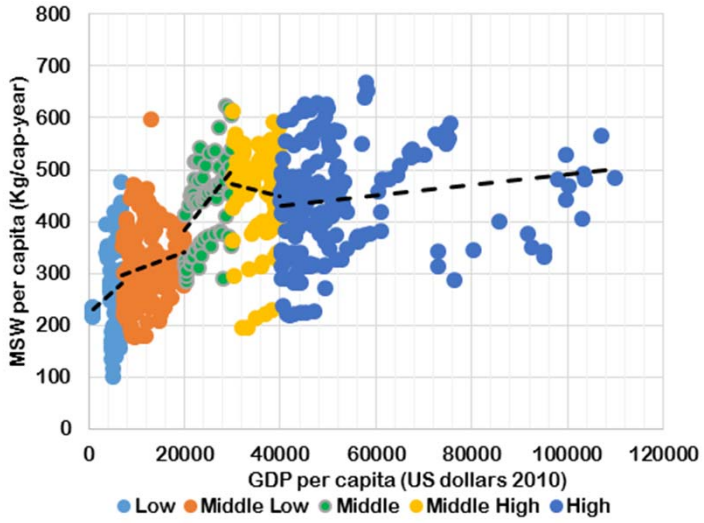
Gains waste matrix

Solid waste management technology	Municipal solid waste								Industrial solid waste				
	Food	Glass	Metal	Other	Paper	Plastic	Textile	Wood	Food	Pulp and paper	Rubber	Textile	Wood
Open burned	X			X	X	X	X	X	X	X	X	X	X
Scattered and/or disposed to water-courses	X	X	X	X	X	X	X	X	X	X	X	X	X
Unmanaged solid waste disposal site - low humidity - < 5m deep	X			X	X		X	X	X	X		X	X
Unmanaged solid waste disposal site - high humidity - > 5m deep	X			X	X		X	X	X	X		X	X
Compacted landfill	X	X	X	X	X	X	X	X	X	X	X	X	X
Covered landfill	X			X	X		X	X	X	X		X	X
Landfill gas recovery and flaring	X			X	X		X	X	X	X		X	X
Landfill gas recovery and used	X			X	X		X	X	X	X		X	X
Low quality burning of waste	X			X	X	X	X	X	X	X	X	X	X
Incineration (poor air quality controls)	X			X	X	X	X	X	X	X	X	X	X
Incineration (high quality air pollution controls - energy recovery)	X			X	X	X	X	X	X	X	X	X	X
Anaerobic digestion	X								X				
Composting	X								X				
Recycling		X	X		X	X	X	X					X

MSW generation - projections

Activity drivers: GDP per capita – Urbanization rate

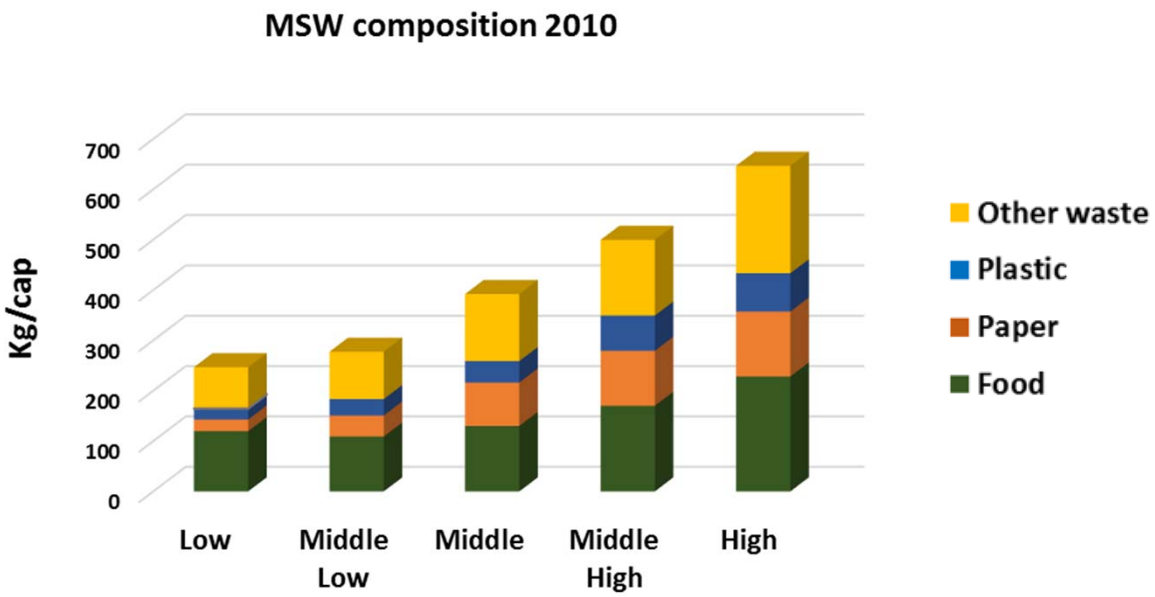
Projections of Total MSW generation based on the elasticity to GDP/cap and urbanization rate for different income groups. Future growth in food waste generation suppressed at higher income levels due to its inferior goods nature.



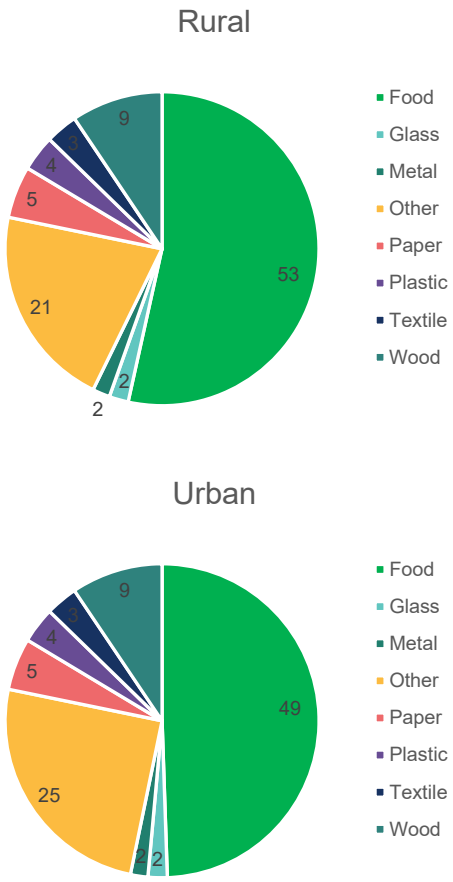
GDP per cap US dollars 2010	ε Income	ε Urbanization Rate
< 7000	0.39	*
>=7000 - <20000	0.25	*
>=20000 - <30000	0.54	*
>30000 - <40000	0.8	-3.28
>=40000	1.08	-1.28

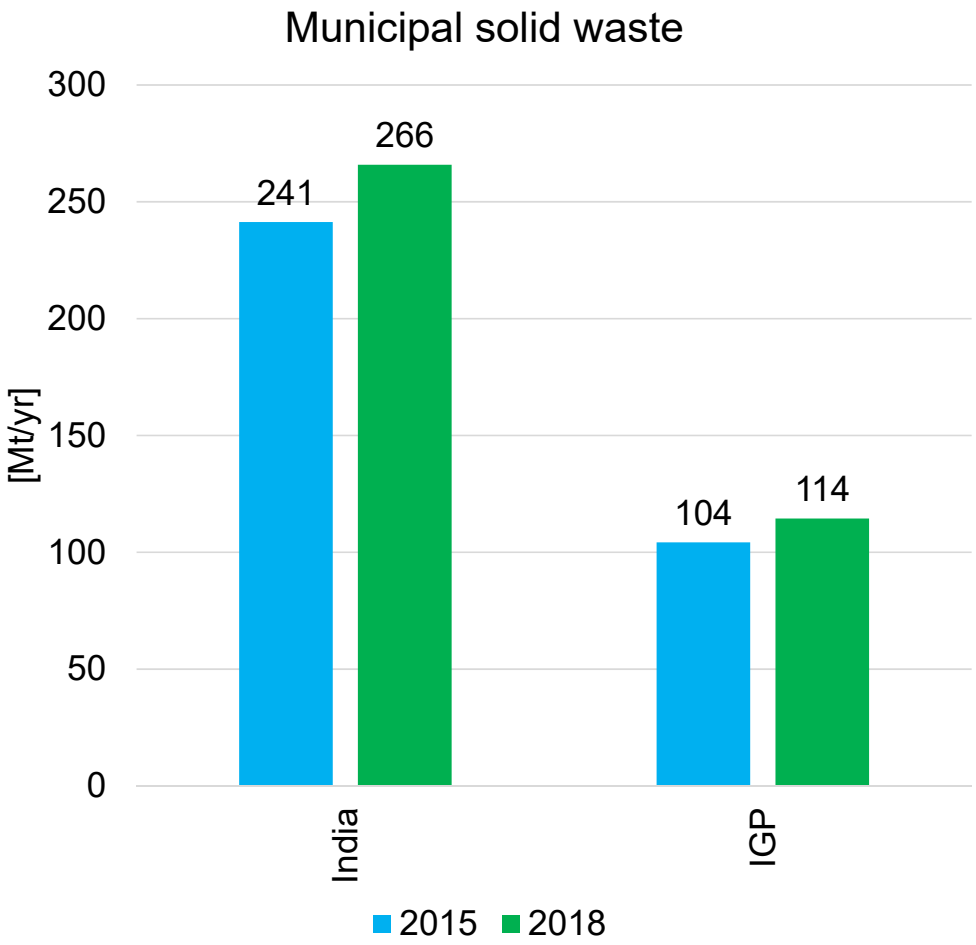
Waste fraction	ε Income
Food waste	0.43

MSW generation - Composition

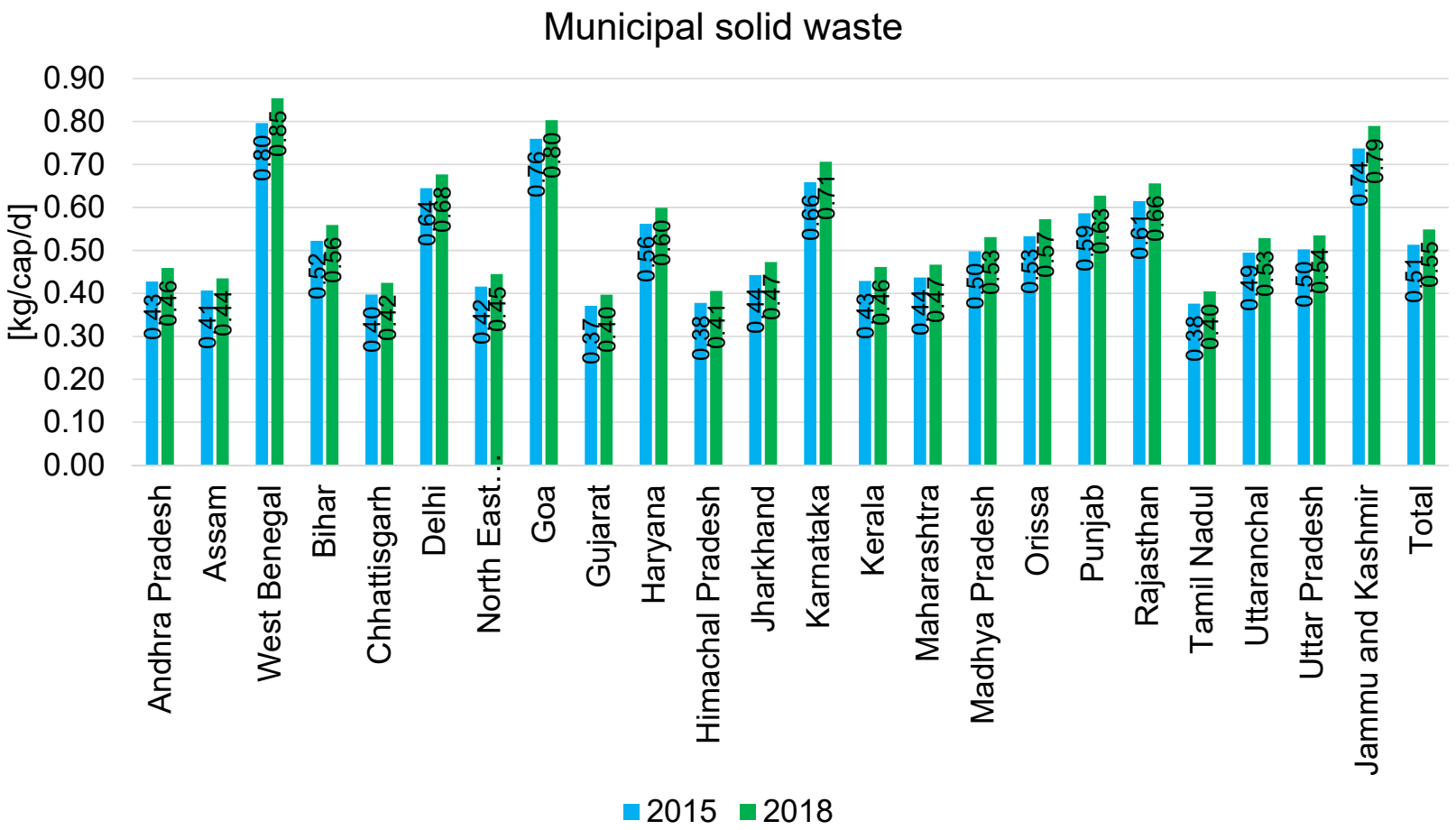


India MSW generation and treatment - 2015





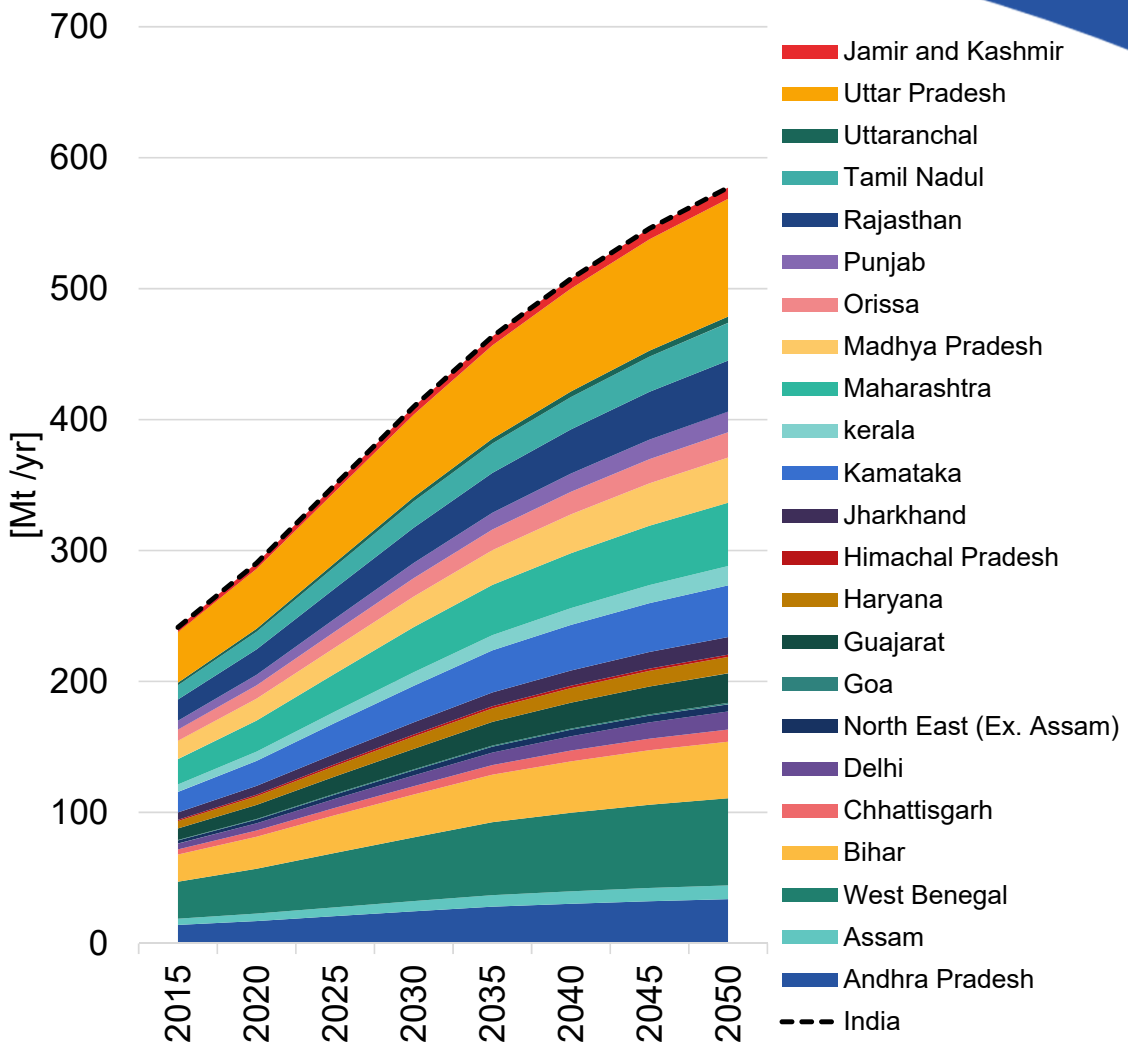
Municipal solid waste generation per capita



MSW up to 2050 - India

MSW 241 Mt/yr (based on Sharma et al.,2019 (201 – 232 Mt/yr))

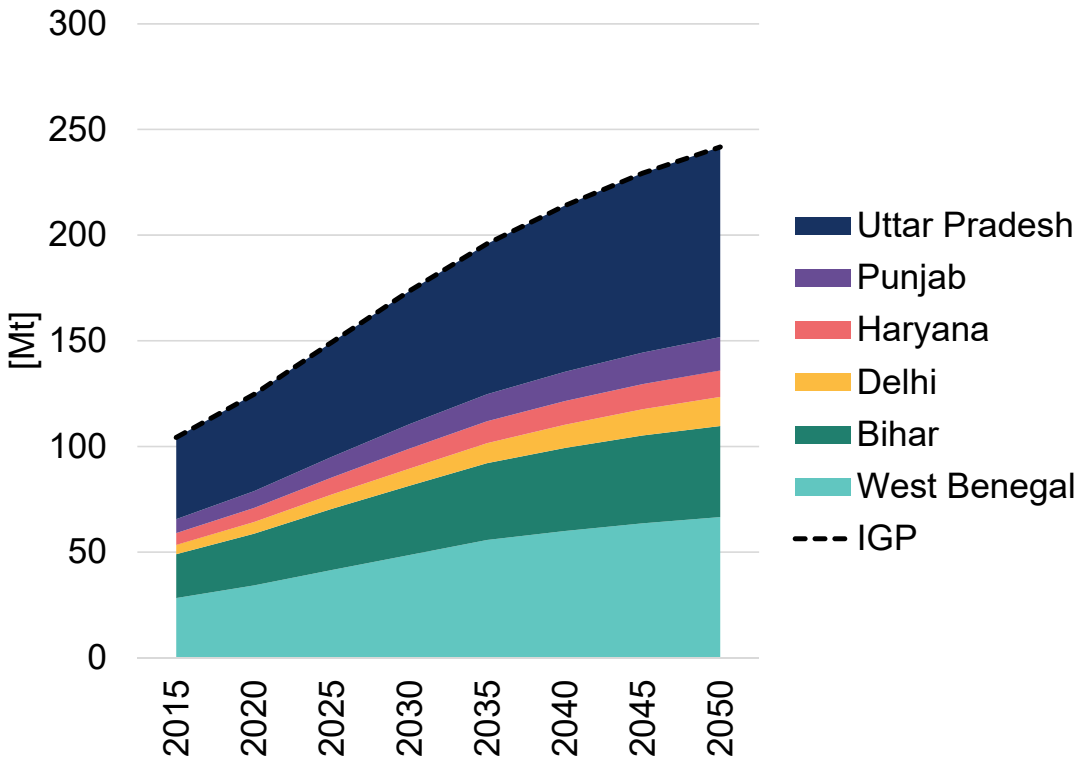
Expected to increase up to 577 Mt/yr in 2050



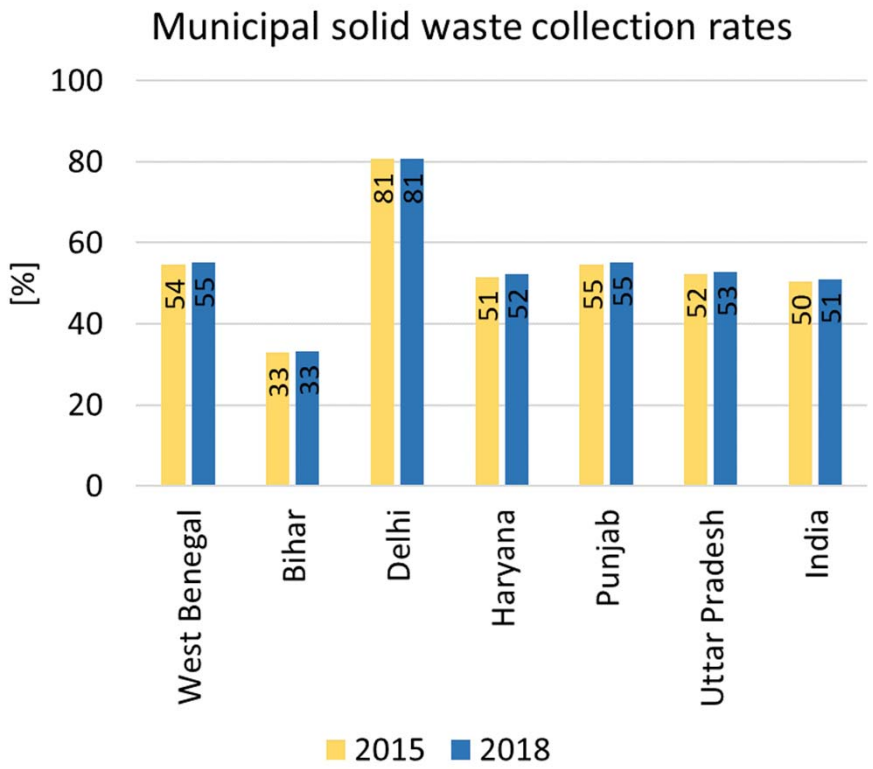
MSW up to 2050

Current IGP 104 Mt → 242 Mt in 2050

IGP 43% of MSW generates in India

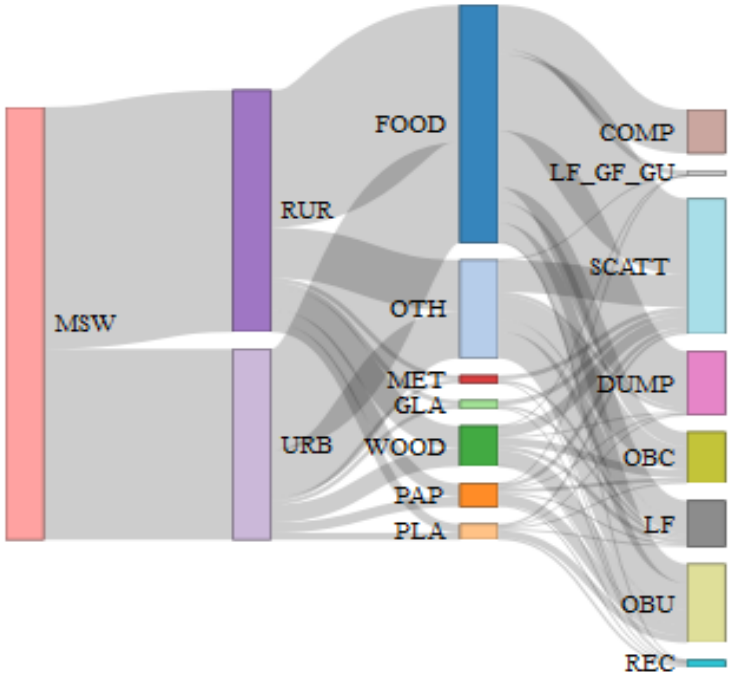


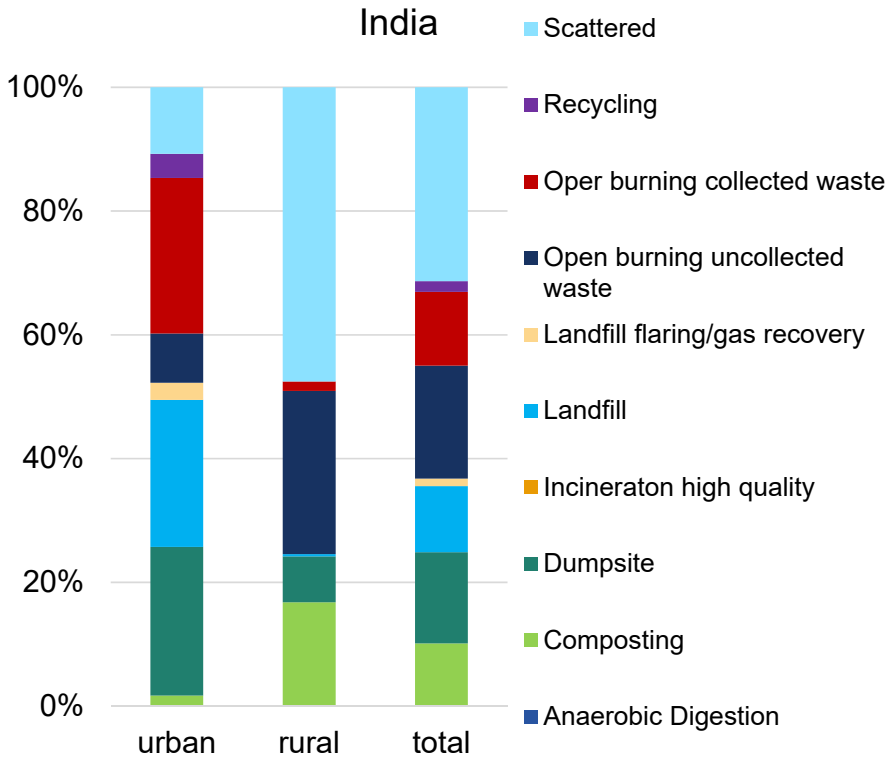
Municipal Solid Waste Collection Rates



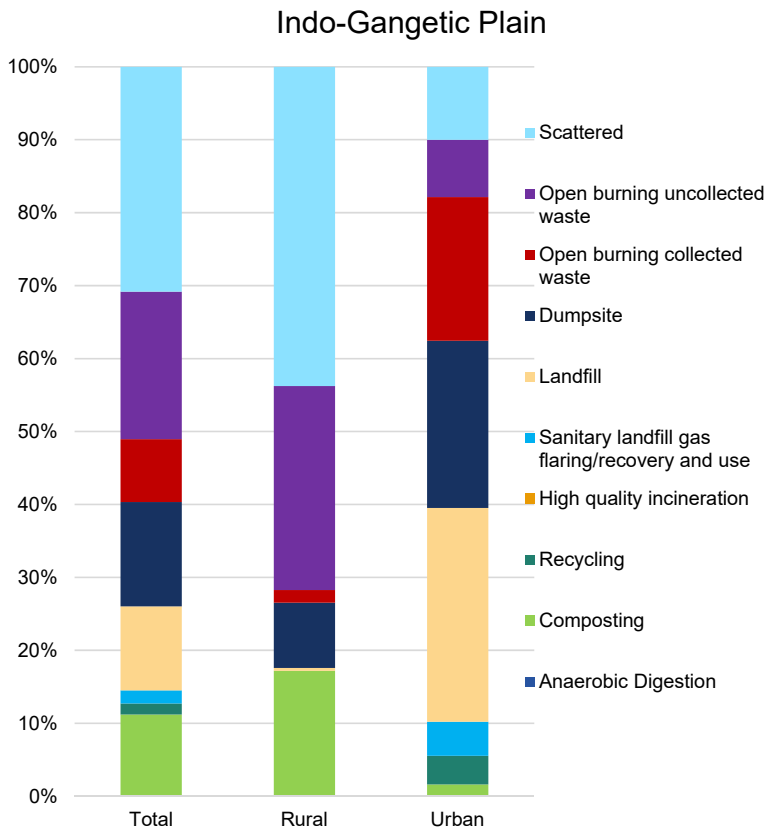
Most of the waste collected is mixed. Not waste segregation at source.

Municipal solid waste treatment





Municipal solid waste treatment 2015



~ 29% of the total waste generated is openly burnt

~31% is scattered waste (with high probability of contaminating water courses)

Although urban areas have high collection rates, ~23% end up in dumpsites

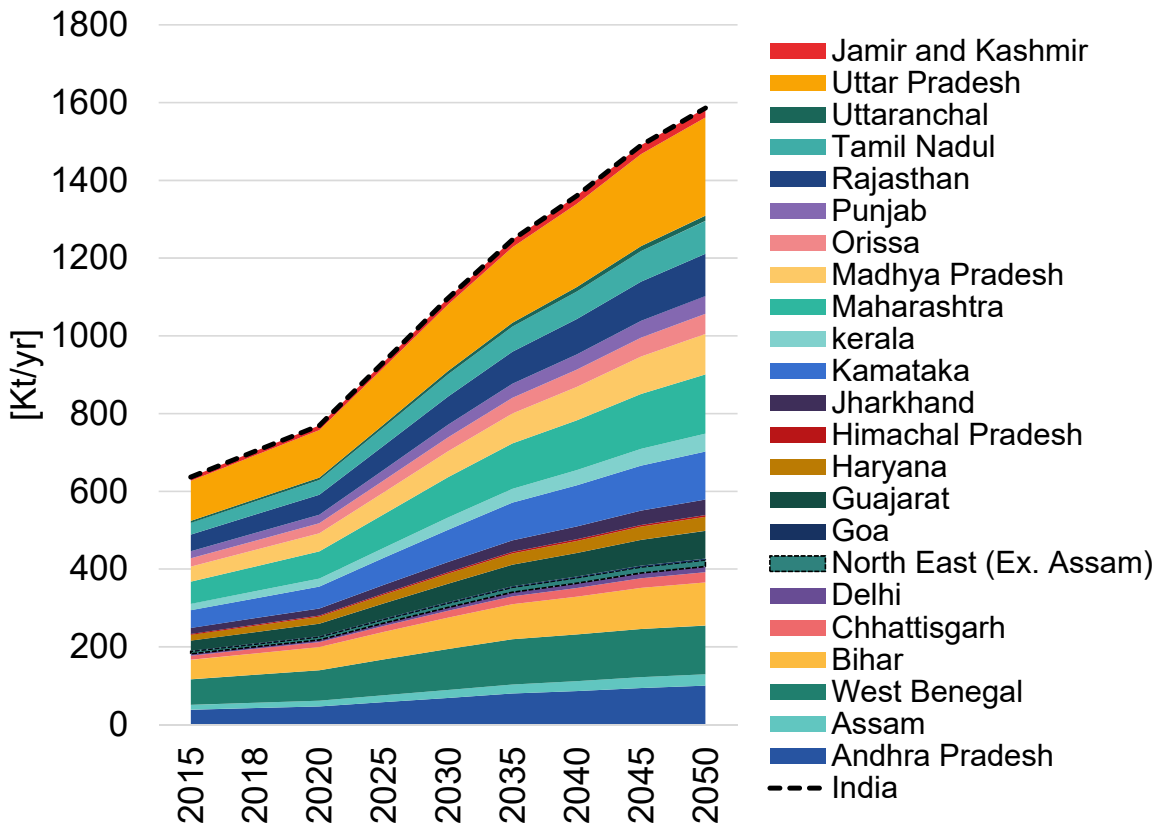
Informal recycling

Waste to energy technologies are limited and also methane recovery from landfills

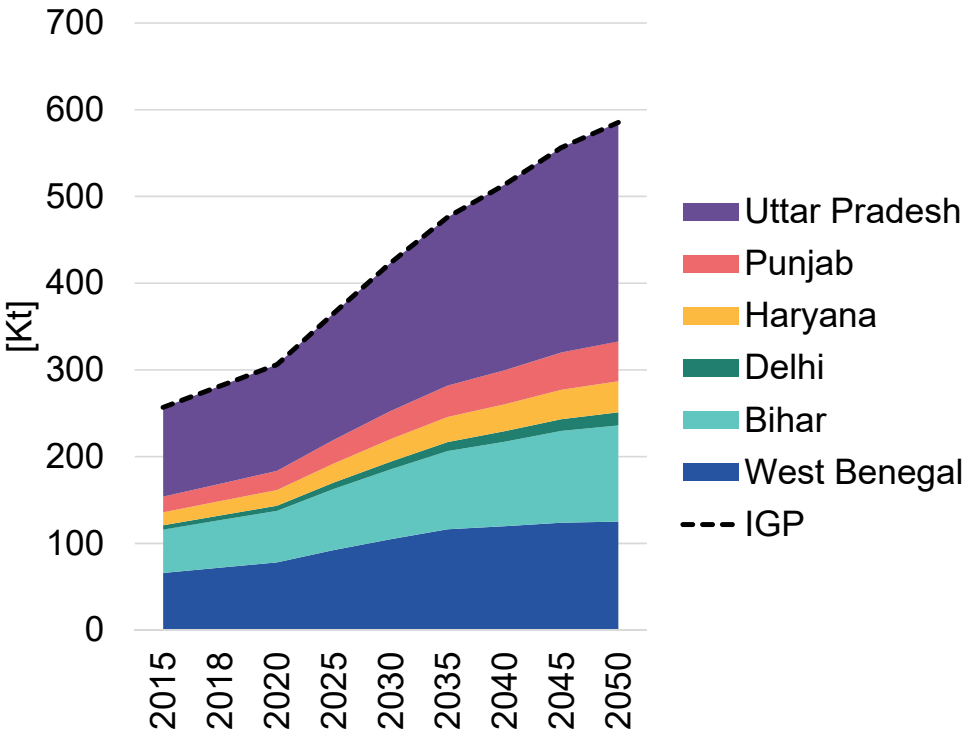
Composting plays a significant role in rural areas

Emissions PM2.5

Currently PM2.5 emissions from municipal solid waste account for ~10% of the total PM2.5 emissions in India



Emissions PM2.5

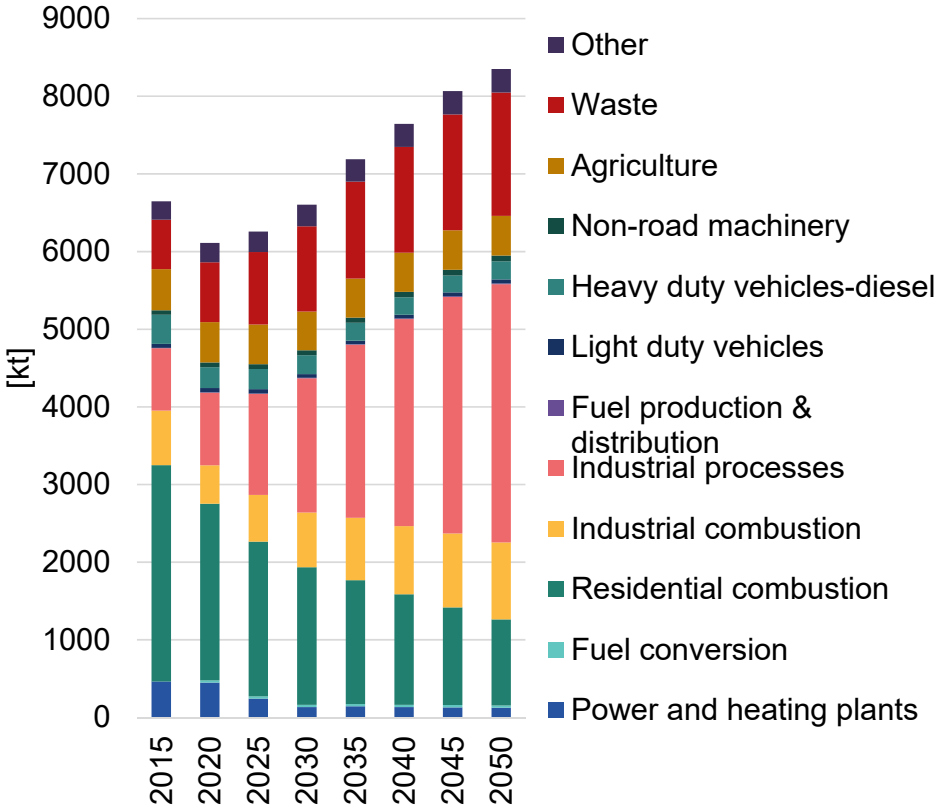


Currently PM2.5 emissions from municipal solid waste account for ~10% of the total PM2.5 emissions in India

IGP accounts for 40% of PM2.5 emissions from municipal solid waste

IGP 2015 - 257 kt PM2.5 – Projected to grow to 585 kt by 2050

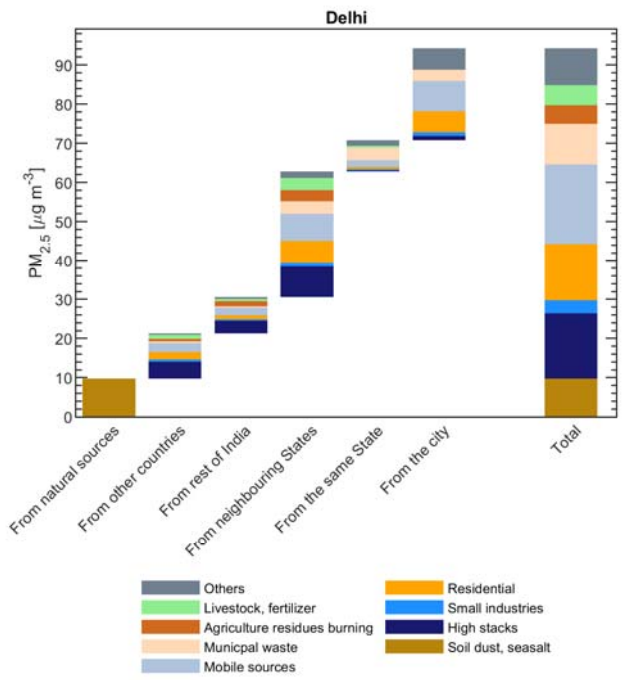
Emissions PM2.5

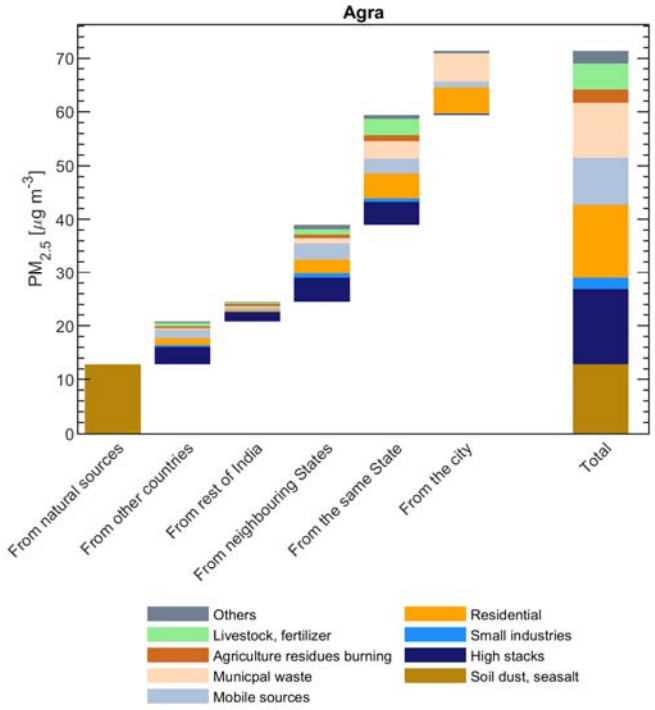


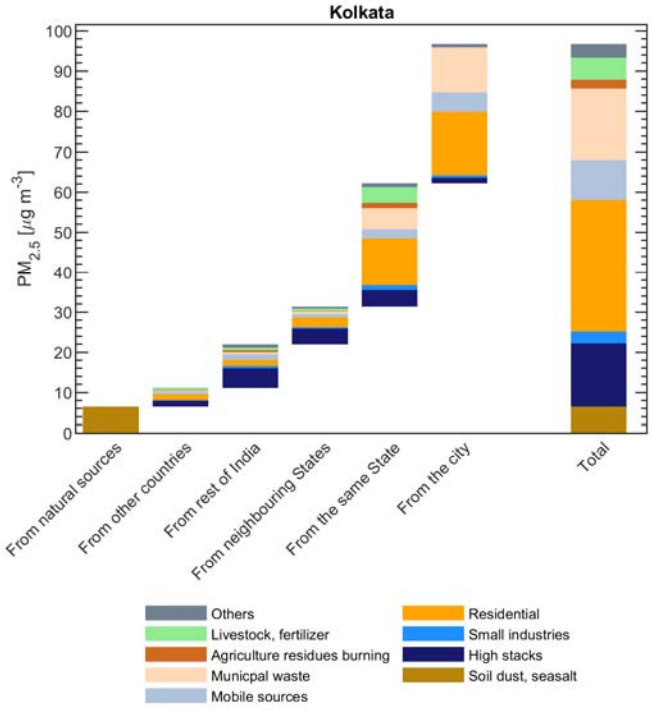
Currently PM2.5 emissions from municipal solid waste account for ~10% of the total PM2.5 emissions in India

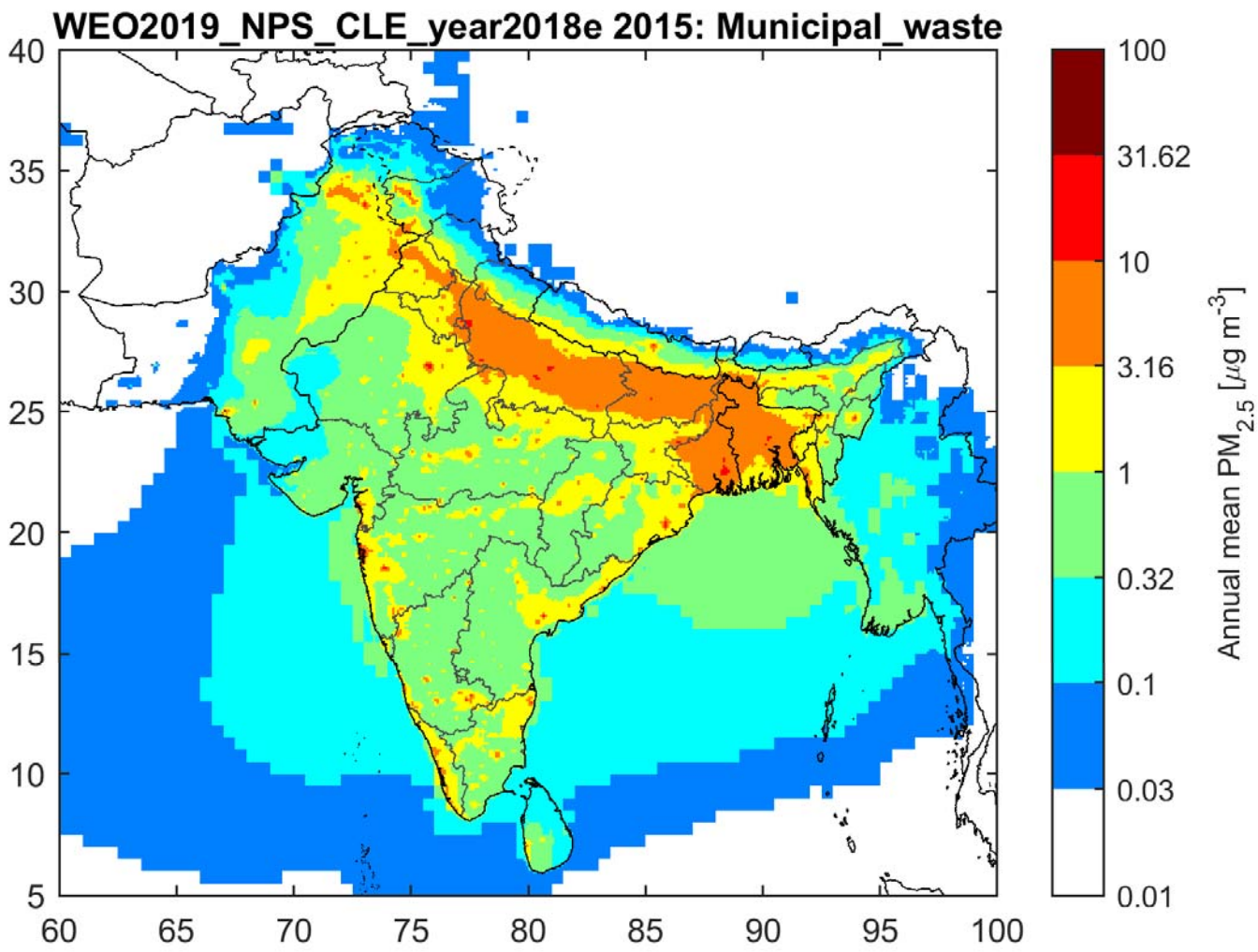
Projected to be 19% in 2050 under the current conditions

Sectoral contribution PM2.5








WEO2019_NPS_CLE_year2018e 2015: Municipal_waste
40
35
30
25
20
15
10
5
60
65
70
75
80
85
90
95
100
100
31.62
10
3.16
1
0.32
0.1
0.03
0.01
Annual mean PM2.5 [μg m-3]

Municipal Solid Waste - Maximum Technical Feasible Emission Reduction

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Source	Measure	Description	Phase – in	Policy instrument
Waste management 	-closing/upgrade dumpsites -avoid open burning of waste	Divert waste from dumpsites and landfills based on the 3Rs strategy. Ban on open burning of waste	100% in 2035	National Solid Waste Management Plans
Collection 	- segregate the waste at source into biodegradables, dry waste, and other type of waste.	Increase the collection of separate waste in urban and rural settings	100% in 2035	National Solid Waste Management Plans
Organic waste 	- divert organic waste from dumpsites /landfills	Biodegradable processed and treated through composting or anaerobic digestion in urban and rural areas.	100% in 2035 Intermediate targets: 50% 2025 75% 2030	National Solid Waste Management Plans

Maximum Technical Feasible Emission Reduction

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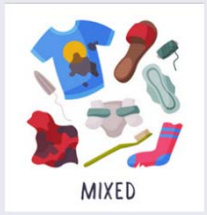
Source	Measure	Description	Phase – in	Policy instrument
Plastic, paper, glass, metal and textile waste 	-increase recycling rates	Maximum recycling rates as follows: Plastic 80% Paper 90% Glass 90% Metal 90% Textile 90%	Intermediate targets: Plastics, metal, wood: 60% 2025, 70% 2030, 80% 2035 Paper, textile: 50% 2025, 65% 2030, 90% 2035 Glass: 60% 2025, 70% 2030, 90% 2035	National Solid Waste Management Plans
Other waste 	- divert waste from dumpsites /landfills	Waste going into high quality incineration with energy recovery	Reach 100% in 2035	National Solid Waste Management Plans

Overarching

1. Studies on emission outlook in each sector, i.e, new forthcoming legislation or even general trends in each sector (projections)? Level of implementation of current legislation? Information about achieving targets

2. Mitigation opportunities – local studies of technologies used to reduce emissions of air pollutants in given sectors; information about typical operational reduction efficiencies

3. Are the principal options to reduce emissions available in GAINS for a given sector, acceptable way to represent mitigation potential? Anything missing? Anything not applicable (see next question)?

4. What are the limitations in introducing certain options – applicability (including also timeline of potential introduction of measures)

5. Is there local experience/information about costs of technologies