Session [#]

Waste Management and Climate Change

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Purpose Statement

The purpose of this presentation is to share the current knowledge related to the interaction between waste management and climate change. In the background of the presentation is the current situation in Egypt's municipal solid waste management. This includes current practices and challenges.

Presentation Outline

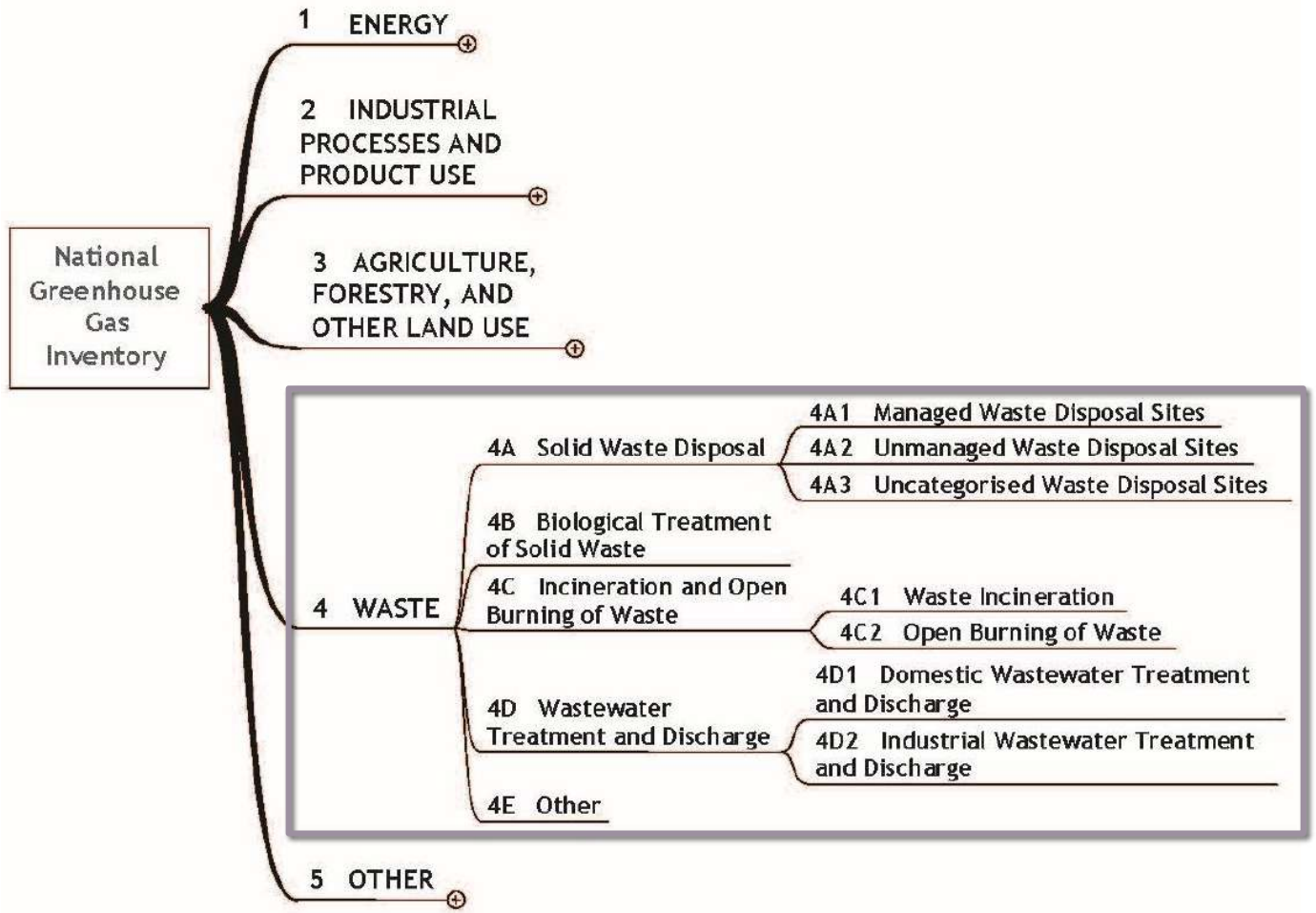
1. Waste Management as Shown in the IPCC Guidelines
2. Our Waste management Model
3. The Interaction Between Waste Management and CC
4. Global Trends: Few Examples
5. Strategies and Policies: Mitigation and Adaptation
6. Proposed Mitigation Approach under Local Conditions
7. Concluding Remarks

Annex: ROCKs

1. Waste Management as Shown in the IPCC Guidelines

Waste Management as Part of the National Greenhouse Gas Inventory

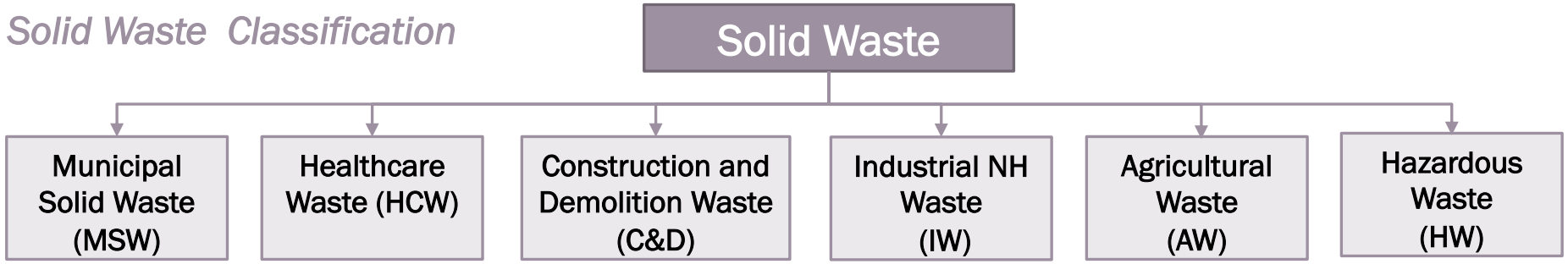
2006 IPCC Guidelines for National Greenhouse Gas Inventories



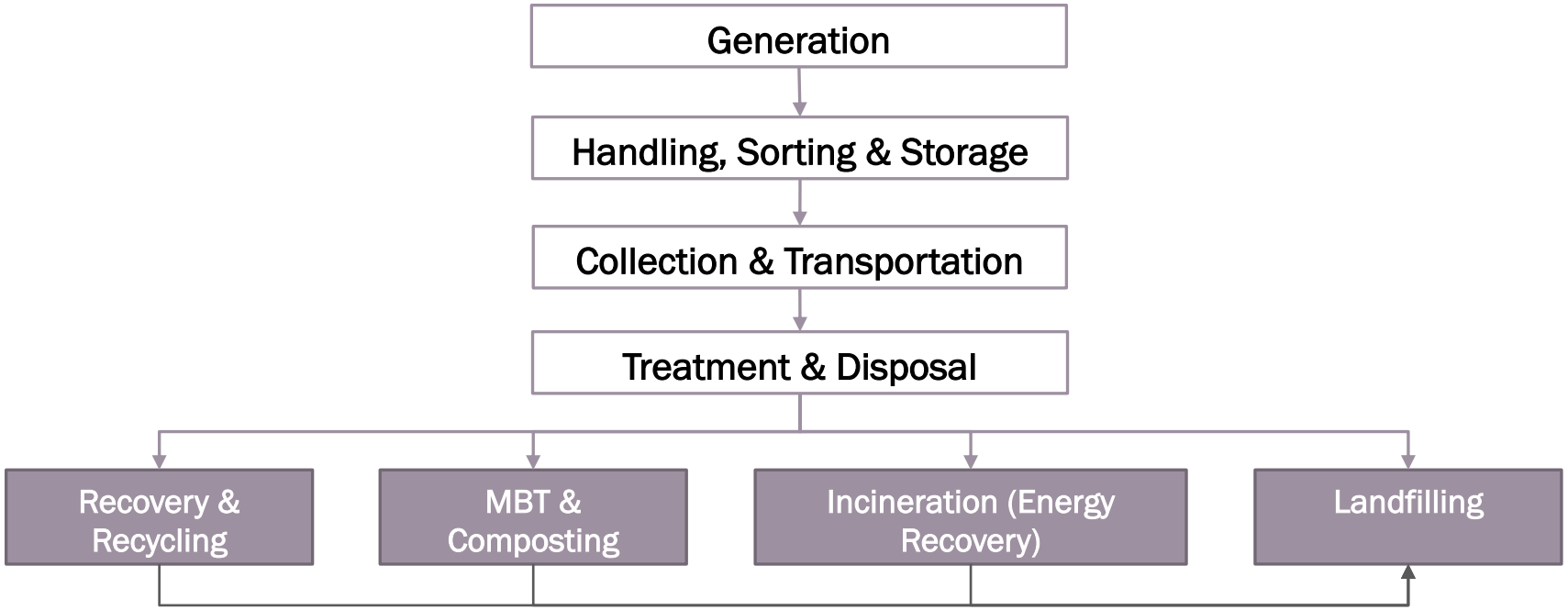
Source: https://www.ipcc-nggip.iges.or.jp/public/2006gl/vol5.html

Solid Waste Classification and Management

Solid Waste Classification



Waste Management Processes



Classification of Waste Generated according to Source

No.	Waste source	Typical facilities and activities generating wastes
1	Residential	Includes single and multi-story houses and high density apartments. Type of solid waste includes: food waste, rubbish, ashes and special wastes.
2	Commercial	Includes stores, restaurants, markets, office building, hotels, medical facilities etc. Type of waste includes food waste, rubbish, ashes, demolition and construction wastes, hazardous wastes.
3	Institutional	Schools, hospitals, police stations, governmental centers etc. Waste similar to residential and commercial is produced in these establishments.
4	Municipal	The term Municipal Solid Waste (MSW) is used for mixed or source-separated waste generated from residential, commercial and institutional facilities
5	Industrial	Generated from repair shops, gas stations, small industries. Typical small industries include: clothing, furniture, printing, leather, food. Type of waste includes MSW, hazardous wastes and industrial non-hazardous waste
6	Open Areas	Includes streets, vacant lots, play grounds, beaches, recreational areas etc. Type of waste includes special waste and rubbish.
7	Inner-city utilities	It includes water and wastewater pumping stations and Scalping plants . Waste is principally composed of screenings, residual sludge and other minor components.
8	Green areas	It includes biomass generated from parks, gardens, urban agriculture, trees trimmings

MSW Categories and Characterization

Secondary categories	Primary categories
1. Food waste 2. Yard waste 3. Other Biodegradable	1. Organics
4. Untreated 5. Treated	2. Wood
6. High gloss paper/card and wallpapers 7. Paper/ card - packaging 8. Newspapers	3. Paper
9. PETE 10. HDPE 11. Low quality plastics 12. Other hard plastics	4. Plastics
13. Clear Glass Container 14. Color Glass Container 15. Miscellaneous Non Packaging Glass	5. Glass
16. Clothes (Synthetic) 17. Clothes (Non-synthetic) 18. Non-clothing textiles	6. Textiles
19. Ferrous Packaging 20. Non-ferrous Packaging 21. Miscellaneous Ferrous and Non-ferrous	7. Metals
22. Batteries/ Accumulators 23. Miscellaneous hazardous waste	8. Hazardous
24. Composite /Complex packaging 25. Composite/ Complex Non-packaging	9. Composite
26. waste of electrical and electronic equipment	10. Mixed WEEE
27. Soil, Stones and other inerts	11. Inert
28. Household health care	12. HH Medical
29. <10mm	13. Fine particles
30. Liquid leftover and leachate	14. Liquids

Particle size classes

- >77 mm
- 55-77 mm
- 14-55 mm
- <14 mm

A. Chem. Composition

1. Carbone, 2. Nitrogn
3. Hydrogen, 4. Oxygen
5. Sulphur, 6. Chlorine
7. Phosphorous,
8. Heavy Metals 9.Water content, 10. Ash

The type and intensity of land uses, along with other community characteristics, will determine the quantity of MSW generated, its categories and characterization.

2. Our Waste Management Model

Service Provision Planning (SPP): Scope

تم تطوير نموذج لتخطيط مشروعات الإدارة المتكاملة للمخلفات الصلبة ودراسة الأثر البيئي لهذه المشروعات علي مستوي منطقة الخدمة Service Provision Area, SPA أو مجموعة من مناطق الخدمة Cluster of SPAs.

Waste Generation and Community-Level Management

Waste Transfer and Transport

Waste Recycling

Waste Processing

Waste Disposal

Service Provision Planning (SPP): Functions

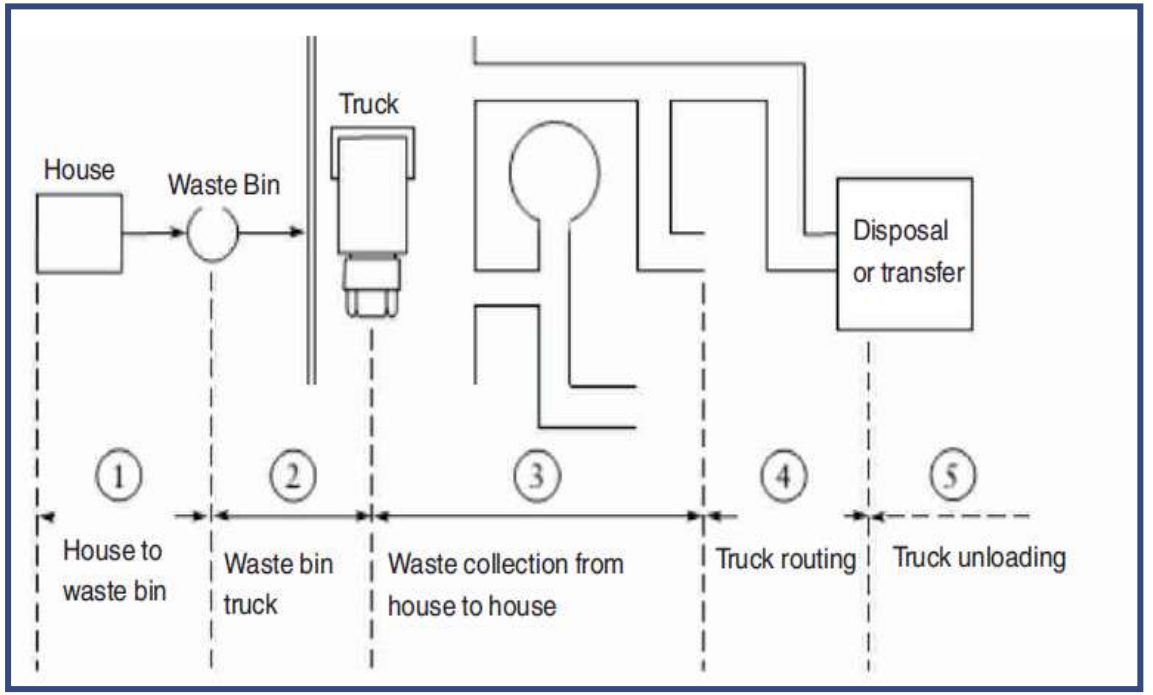
The Service Provision Plan divides all works and waste management related activities into five separate FUNCTIONs (Fs). Each function specifies the spectrum of applied technologies and the associated energy requirements and emissions.

F1

Function1: Waste Generation and Community-Level Management

Waste collection system defines: types of container, frequency of collection, types of collection services and routes as well as its user acceptance.

Most important for the design of a MSW collection system in SPA are: population, quantities of waste generated, waste composition, climate conditions, existing waste treatment facilities, public waste storage/disposal behavior, end product utilization, funding



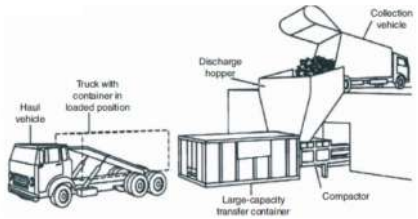
Function2: Waste Transfer and Transport

F2

Transfer and transport refers to the means, facilities and equipment used to affect the transfer of waste from one location to another (usually to more distant location).

Typically, the waste from relatively small collection vehicle is transferred to larger vehicle and is transported to distant location for further processing and safe disposal.

Transfer stations



Material Recycling Facilities, MRF (three types):
Dirty, Clean and Hybrid



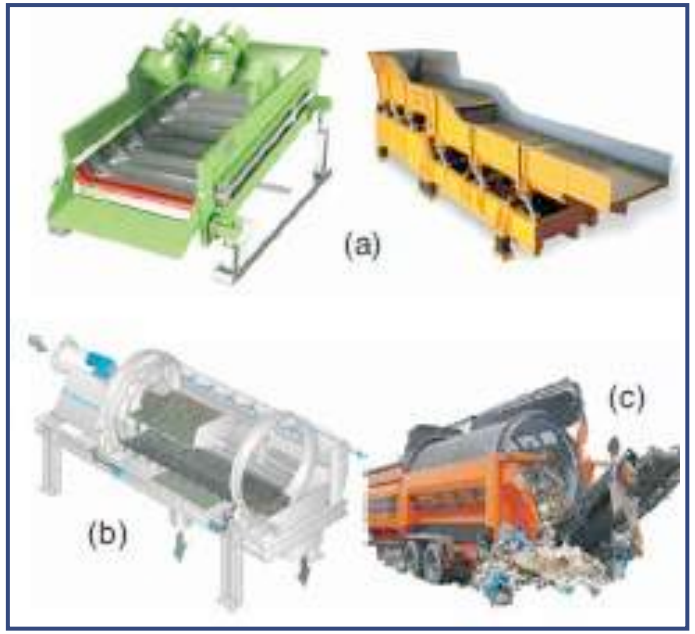



Function3: Waste Processing

F3

Waste Processing for Efficiency Improvement:

- Densification
- Mechanical Shredding
- Component Separation
- Moisture Reduction



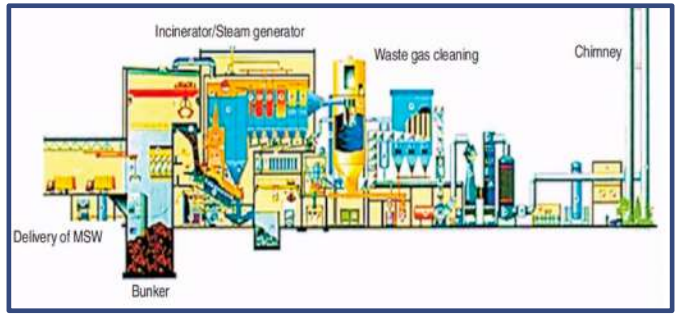
(a) Vibrating screens, (b) Rotary drum screen, © Trommel screen

Waste Processing for Material Recovery:

- Recovery of recyclables
- Recovery of the Energy Rich Fraction (ERF)
- Recovery of the biodegradable fraction (OFMSW) in the form of compost

Waste Processing for Energy Production:

- Incineration (mass burn)
- Gasification
- Pyrolysis
- Bio-digestion



Function4: Waste Recycling

F4

Category	Sub-sector
1	Collection and Transportation of All Types of Waste
2	Sorting and Densification of all Types of Waste
3	MSW Treatment and Disposal
4	Waste Glass Recycling
5	Metals Scrap Recycling
6	Paper Recycling
7	Textile Waste Recycling

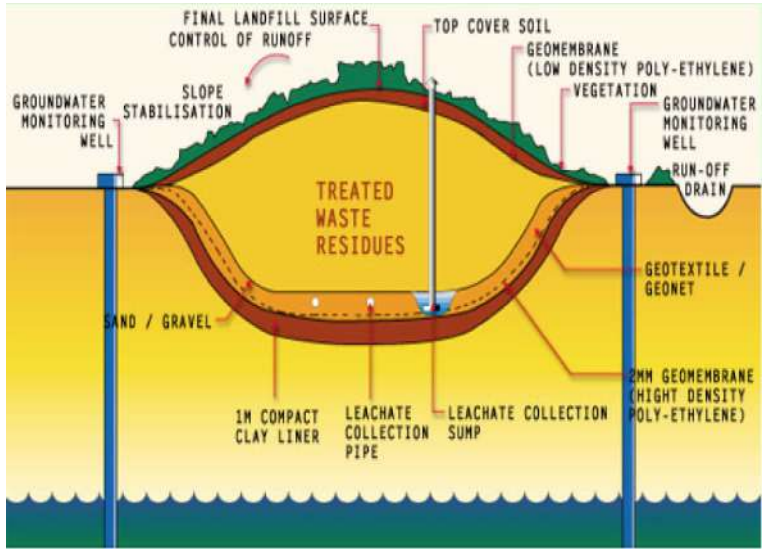
Category	Sub-sector
8	Plastics Recycling
9	Rubber Waste Recycling
10	WEEE Recycling
11	Construction/Demolition Waste Recycling
12	Biomass Recycling
13	Reuse and Remanufacturing Industry
14	Support Businesses

*A.Gaber, Towards a Waste Recycling Industry in Egypt: Building Blocks and Proposed Categorization, May 2018

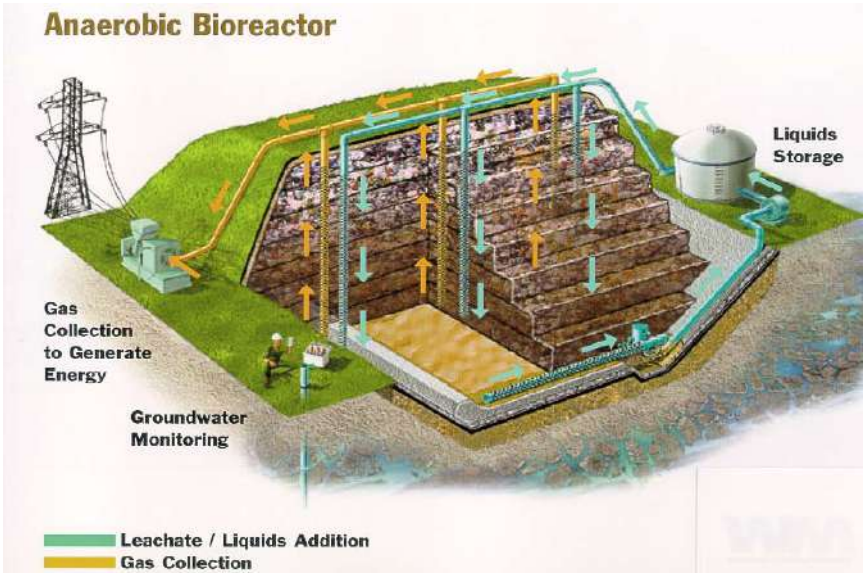
Function5: Waste Disposal

F5

Waste disposal deals with the safe containment of the untreated municipal solid waste, rejected materials coming from the composting facilities, material recovery facilities (MRF) and incineration facilities etc. Rejected or residual materials are those which cannot be recycled.



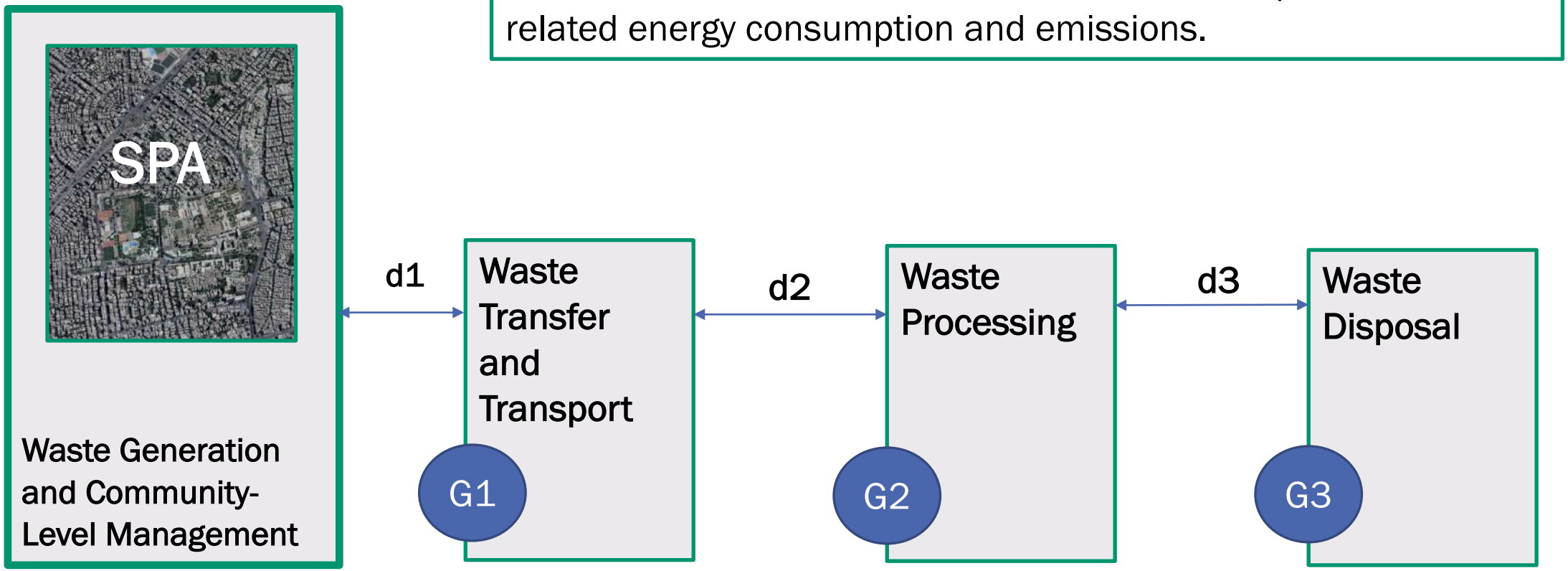
Source: Seoul National University; Design, operation and management of solid waste landfills; Laboratory of waste management and resource recirculation



Source: Don Davies Stantec Consulting Ltd.; 2010; Sustainable landfill biocell

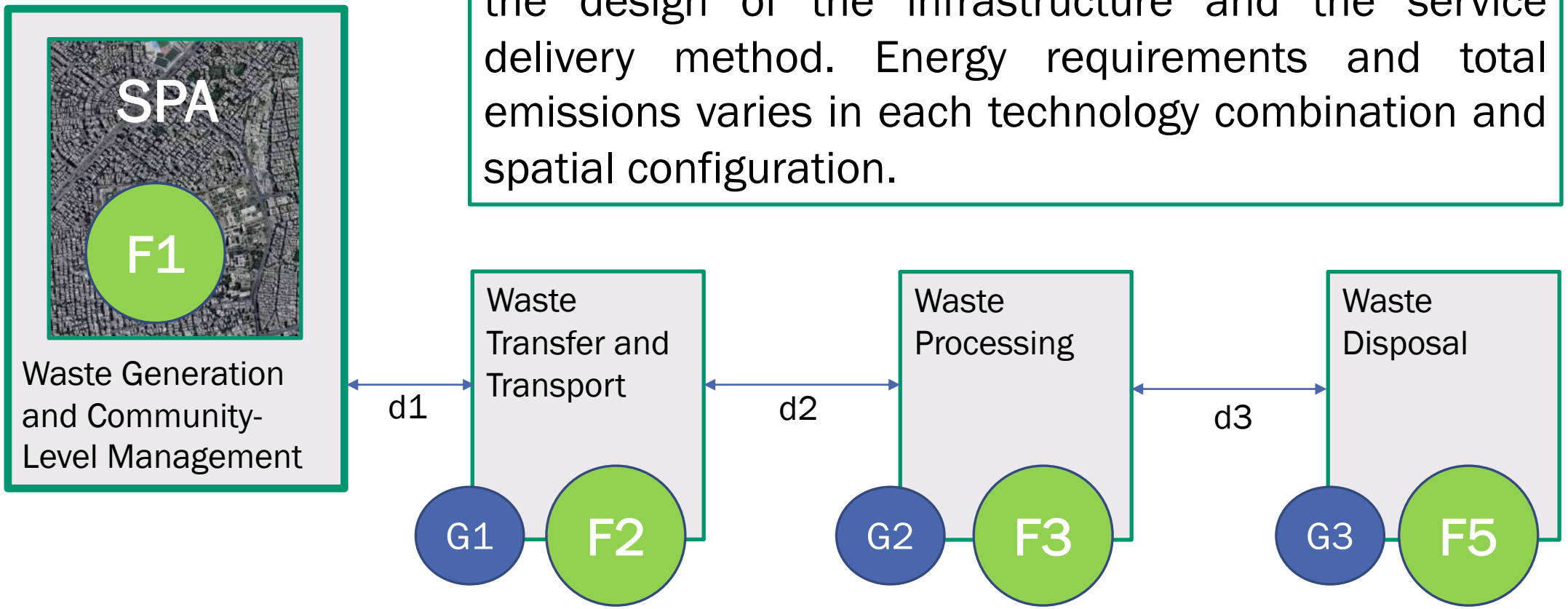
Service Provision Planning (SPP): Gates

The SPA specifies three Gates (Gs). The Gate concept is essential for contractual reasons. The travel distances d1, d2 and d3 determine the economics of waste transportation and related energy consumption and emissions.



Service Provision Planning (SPP): Technology Combination

There are a wide range of technology options. The selection of any technology combination will influence the design of the infrastructure and the service delivery method. Energy requirements and total emissions varies in each technology combination and spatial configuration.



Service Provision Planning (SSP) – Circular Economy Perspective

- Waste reduction programs
- Source segregation programs

- Recovery of recyclables
- Recovery of the ERF

Conversion of the OFMSW to Energy and liquid fertilizer

Minimization of landfilling (to be limited to the reject fraction)

Waste Generation and Community-Level Management

d1

T1

Waste Transfer and Transport

F2

d2

T2

Waste Processing

F3

d3

T3

Waste Disposal

F5

Minimize transportation distances (apply the proximity principle)

3. The Interaction Between Waste Management and CC

ipcc
INTERGOVERNMENTAL PANEL ON climate change

2019 Refinement to the 2006 IPCC Guidelines for National Greenhouse Gas Inventories

Volume 5

Waste

Edited by Calvo Buendia, E., Tanabe, K., Kranjc, A., Baasansuren, J., Fukuda, M., Ngarize S., Osako, A., Pyrozhenko, Y., Shermanau, P. and Federici, S.

Task Force on National Greenhouse Gas Inventories

WMO UNEP

2019

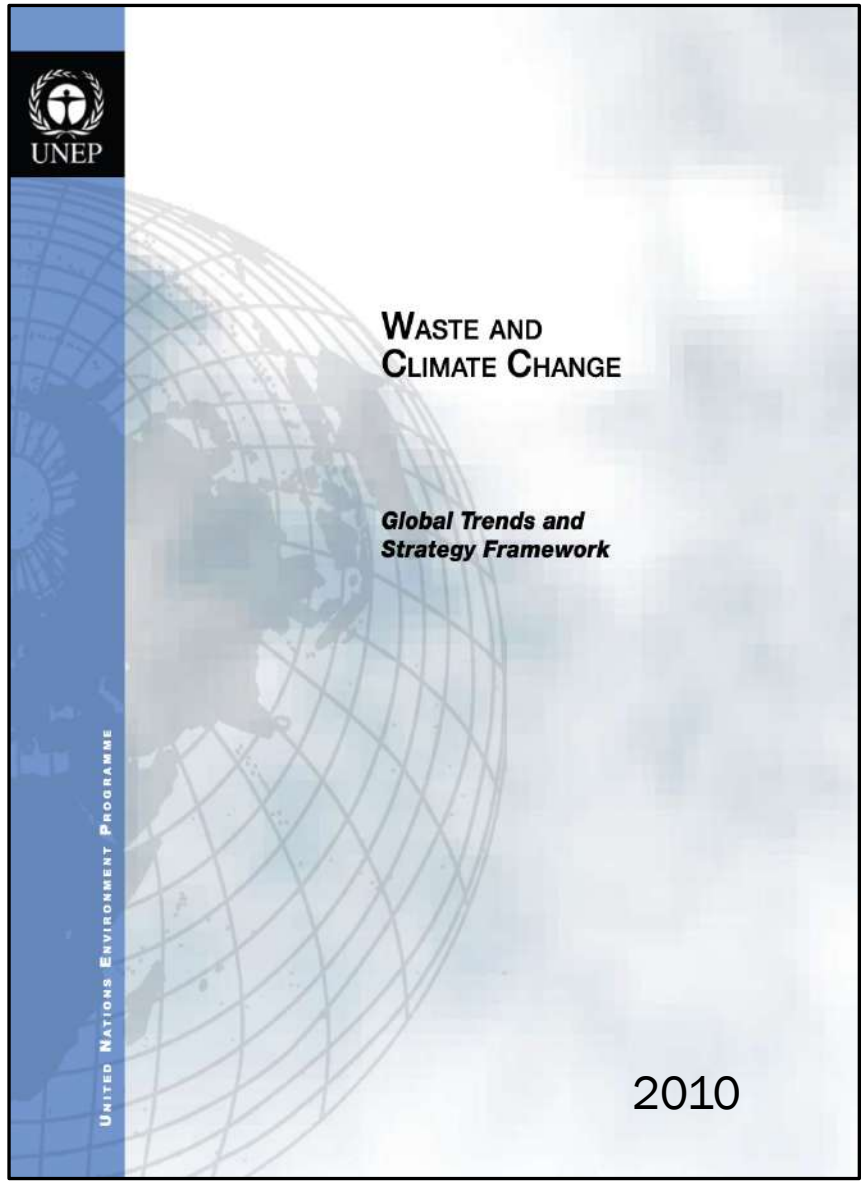
Contents

Major GHGs

- Carbon Dioxide (CO2)
- Methane (CH4)
- Nitrous Oxide (N20)

Less prevalent GHGs

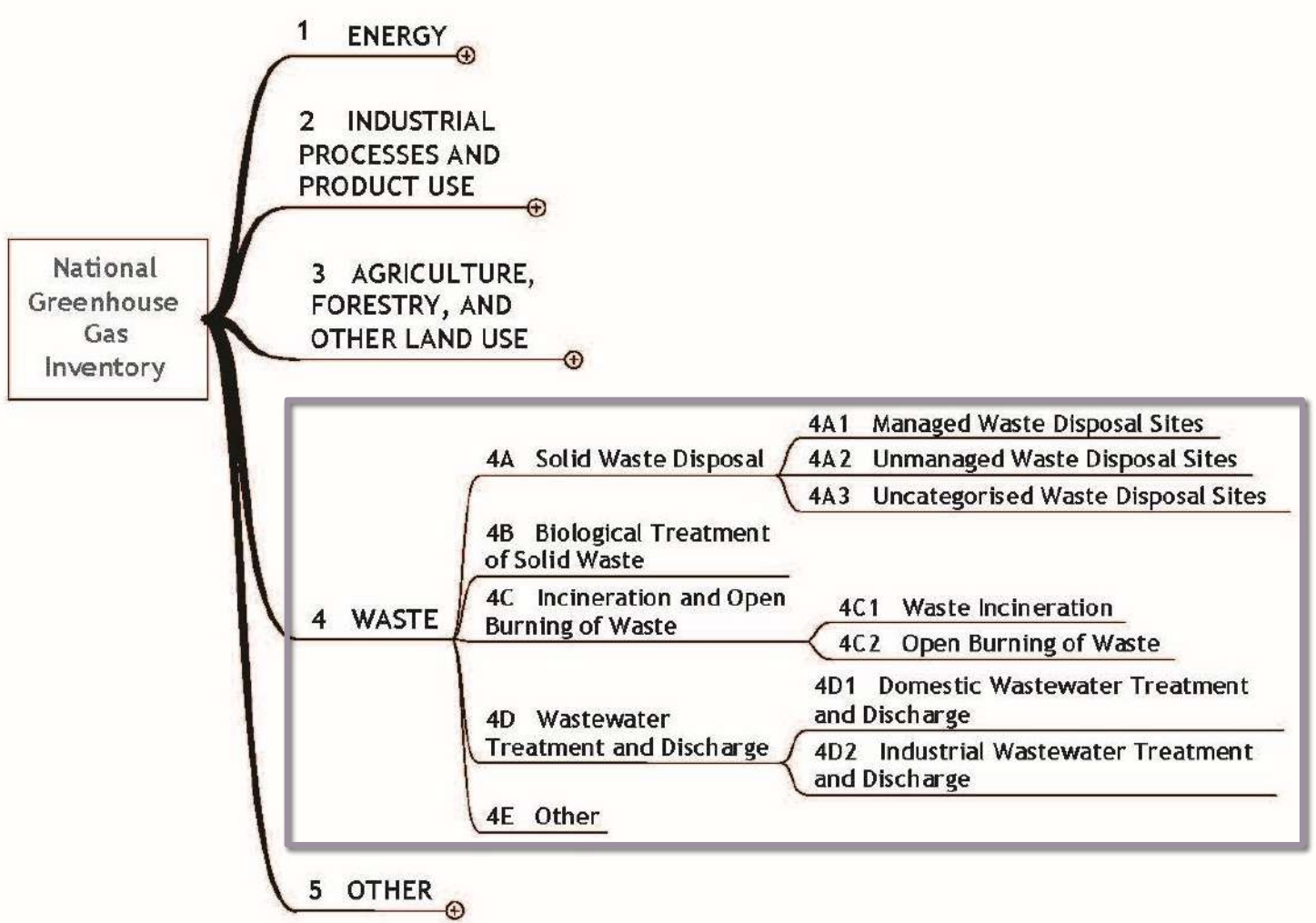
- Hydrofluorocarbons (HFCs)
- Perfluorocarbons (PFCs)
- Sulphur hexafluoride (SF6)



CONTENTS

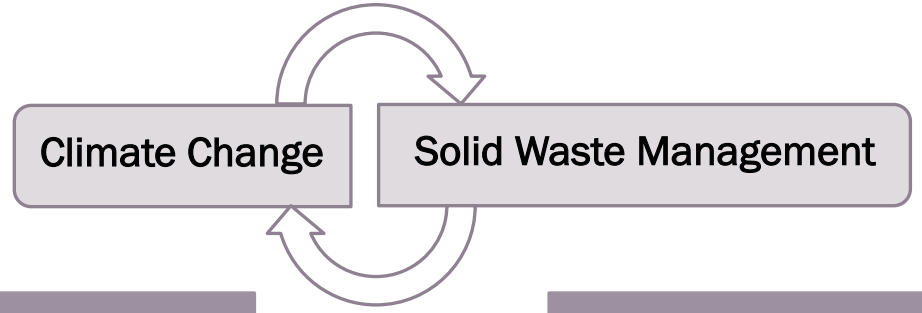
GHGs Emissions from Waste Management

2006 IPCC Guidelines for National Greenhouse Gas Inventories



Source: https://www.ipcc-nggip.iges.or.jp/public/2006gl/vol5.html

The Interaction between CC and SWM



General Climate Change Impacts on Solid Waste Management

Increasing temperatures and heatwaves

- Increase water demand for workers
- Affects biological processes (i.e. composting)

Increasing Precipitation

- Increased risk of flooding
- Disruption of infrastructure
- Affect slope stability of waste management site
- Affects biological processes

Sea-level rise

- Inundation of waste management facilities
- Increased erosion of coastal areas

General Solid Waste Management Impacts on Climate Change

SWM Activities

(i.e. waste treatment and disposal

Greenhouse Gas Emissions

CH4

N2O

CO2

Source: https://www.researchgate.net/publication/332978670_Interrelation_between_Climate_Change_and_Solid_Waste

CC Impacts on Specific SWM Activities -1

CC Impact	Collection	Processing	Disposal
Heat	• Increased odor and pest activity requiring more frequent waste collection. • Overheating of collection vehicles requiring additional cooling capacity, including to extend engine life.	Overheating of sorting equipment	• Altered waste decomposition rates. • Increased maintenance and construction costs due to thawing permafrost. • Increased risk of fire at disposal sites especially in case of droughts.
	Greater exposure of workers to flies, which are a major cause of infectious diseases (flies breed more quickly in warm temperatures and are attracted to organic waste).		
Flooding	• Flooding of collection routes and landfill access roads, making them inaccessible. • Increased stress on collection vehicles and workers from waterlogged waste. • Waste put out for collection washed into streets or waterways.	• Increased need for enclosed or covered sorting facilities.	• Increased flooding in/around sites. • Increased leachate that needs to be collected and treated. • Increased leakage & run-off on dumpsites due to heavy rain.

Sources: https://www.c40knowledgehub.org/s/article/Reducing-climate-change-impacts-on-waste-systems?language=en_US
https://www.climatelinks.org/resources/addressing-climate-change-impacts-infrastructure-preparing-change-solid-waste-management

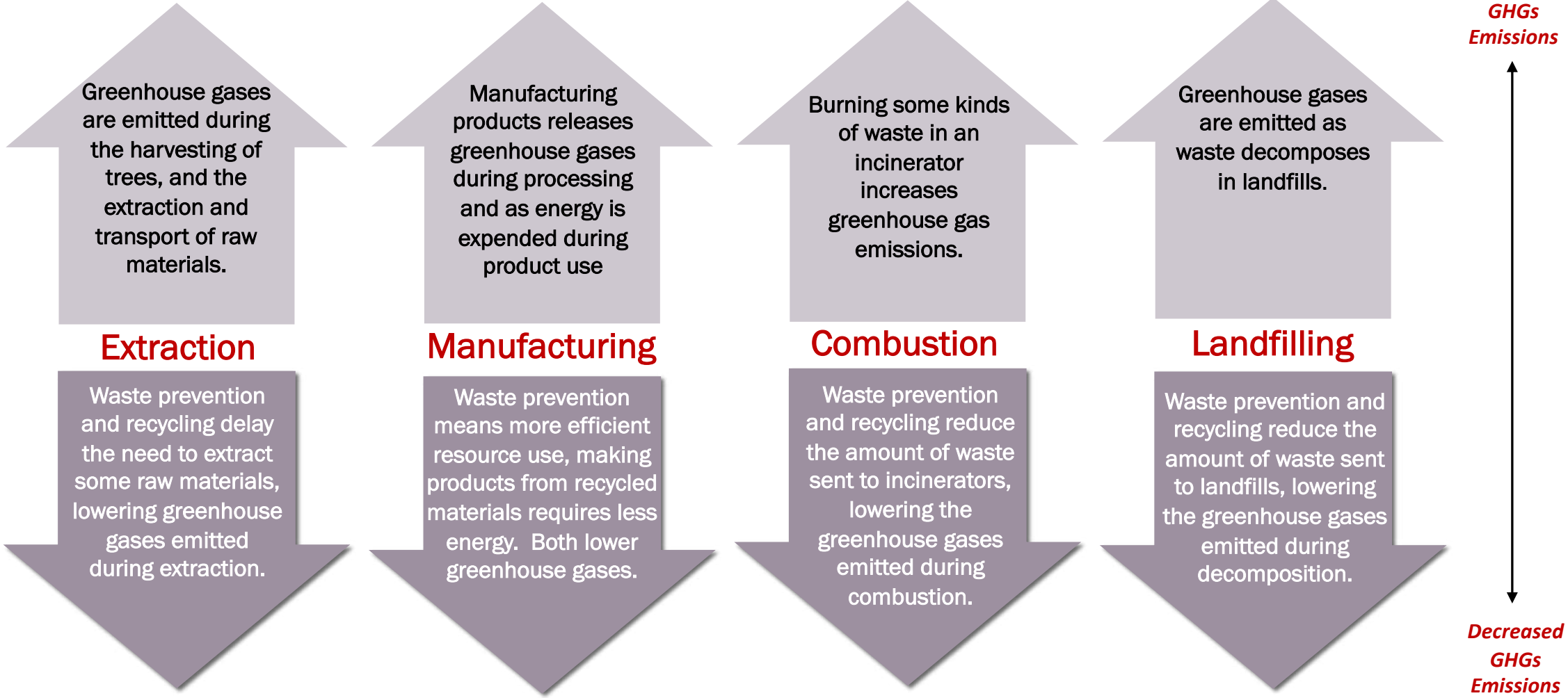
CC Impacts on Specific SWM Activities - 2

CC Impact	Collection	Processing	Disposal
Sea-level Rise	• Narrowed collection routes. • Potentially increased waste in a concentrated area as people crowed into higher elevations within an urban area.	• Damage to low-lying processing facilities. • Increased need for sorting and recycling to minimize waste storage needs.	• Deterioration of impermeable lining. • Water infiltration of pit leading to possible overflow of waste.
	• Permanent inundation of collection, processing, and disposal infrastructure.		
Storm and Wind	• Temporary flooding of and diminished access to roadways, rails, and ports for waste collection, sorting, and disposal. • Closure of facilities due to infrastructure damage. • Dispersal of waste from collection sites, collection vehicles, processing sites & landfills. • Reduced access to collection and landfill access routes due to damage and debris. • Significant waste generation from damage and debris, and from emergency response (tents, disposables, etc.). • Extreme events also represent a risk when affecting other infrastructure system which a waste facility or system depends on. E.g. electricity to run Anaerobic Digestion or to keep track of operations through computer-based ICT; road to perform waste collection and to access facilities;).		

Sources: https://www.c40knowledgehub.org/s/article/Reducing-climate-change-impacts-on-waste-systems?language=en_US
https://www.climatelinks.org/resources/addressing-climate-change-impacts-infrastructure-preparing-change-solid-waste-management

GHGs Emissions from Waste Management - 1

The Link between Waste Management and Greenhouse Gases



Source: http://www7.nau.edu/itep/main/tcc/docs/resources/om_CCMitigationSolidWaste_021215.pdf

GHGs Emissions from Waste Management - 2

Activity	GHGs Emissions
Collection and Transportation	• CO2 from fuel consumption • HFC from A/C leakages
Transfer	CO2 from fuel consumption
Pre-treatment (Dismantling)	CO2 from fuel consumption
Sorting, Recovering & Recycling	• CO2 from fuel consumption • HFC from WEEE dismantling
Physio-chemical Treatment	CO2 from fuel consumption
Biological Treatment (Composting)	• CO2 from fuel consumption • Process emissions (CH4 and N2O)

Activity	GHGs Emissions
Biological Treatment (Anaerobic Digestion)	• CO2 from fuel consumption • Process emissions (CH4 and N2O)
Mechanical-Biological Treatment (MBT)	• CO2 from fuel consumption • Process emissions (CH4 and N2O)
Thermal Treatment (Incineration)	• CO2 from fuel consumption • Process emissions (CO2 and N2O)
Landfilling	• CO2 from fuel consumption • Diffuse CH4 emissions • CH4 from incomplete landfill gas combustion

Source: https://ghgprotocol.org/sites/default/files/Waste%20Sector%20GHG%20Protocol_Version%205_October%202013_1_0.pdf

GHGs Emissions from Waste Management - 3

- ***Landfills*** are a significant contributor to climate change, accounting for approximately ***5%*** of global GHGs emissions and ***95%*** of emissions from the waste sector (***Methane*** emissions from landfill represent the largest source of GHGs emissions from the waste sector).
- The amount of emissions from waste depends on how the waste is treated. GHGs emissions from ***MBT*** < emissions from ***landfilling*** < emissions from ***incineration*** (with no energy recovery).
- ***Composting*** contributes very little to GHG inventories generating only ***0.01–0.06%*** of global emissions.
- <u>Emissions from landfills are a function of the following factors:</u>
  1. The total amount and composition of waste-in-place, which is the total waste landfilled annually over the operational lifetime of a landfill
  2. Characteristics of the landfill (e.g., size, climate, cover material)
  3. The amount of CH4 that is recovered and either flared or used for energy purposes
  4. The amount of CH4 oxidized as the landfill gas – that is not collected by a gas collection system – passes through the cover material into the atmosphere.

GHGs Emissions from Waste Management - 4

Activity	GHGs Emissions	Lifetime (Years)	Global Warming Potential (GWP)	
			20 years	50 Years
Waste Incineration	CO2	Variable/Long	1	1
Collection, transport and treatment of waste (Energy Consumption)	CO2	Variable/Long	1	1
Decomposition of organic waste in landfills	CH4	12	72	25
Composting, biological treatment, waste incineration	N2O	114	289	298
Disposal of electric and electronic devices	HFCs, PFCs, SF6	Various	Various	Various
Uncontrolled/open burning of waste	Black Carbon	0.028	3200	910

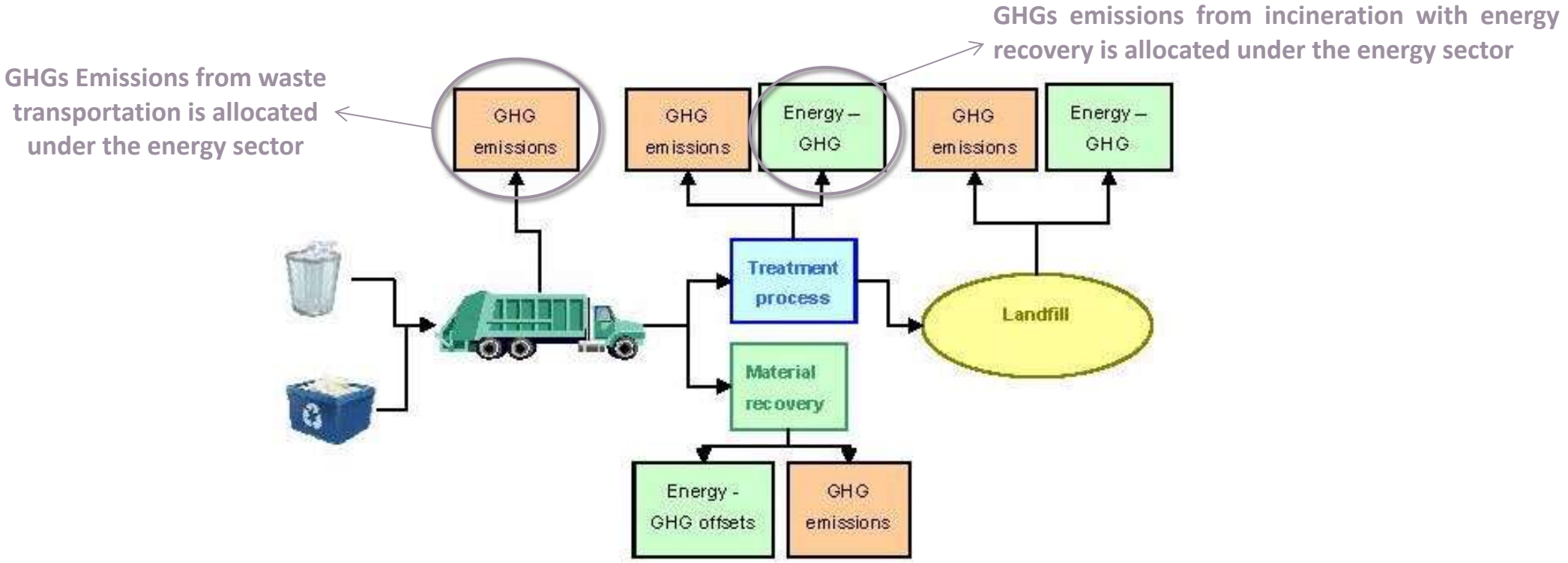
Global Warming Potential (GWP) is a measure of how much energy the emissions of 1 ton of a gas will absorb over a given period of time, relative to the emissions of 1 ton of carbon dioxide (CO2).

GWP of CH4 released from the waste sector are more dangerous as its lifetime extends up to a decade and its heating effect is high for both 20 and 50 years

Source: https://www.researchgate.net/publication/332978670_Interrelation_between_Climate_Change_and_Solid_Waste

GHGs Emissions from Waste Management - 5

- Not all GHGs emissions from waste management activities are allocated under the waste sector in the National GHGs Inventories.
- GHG emissions due to energy used in any sector are calculated in the energy sector.
- Burning of agriculture waste is usually allocated under the agricultural sector.



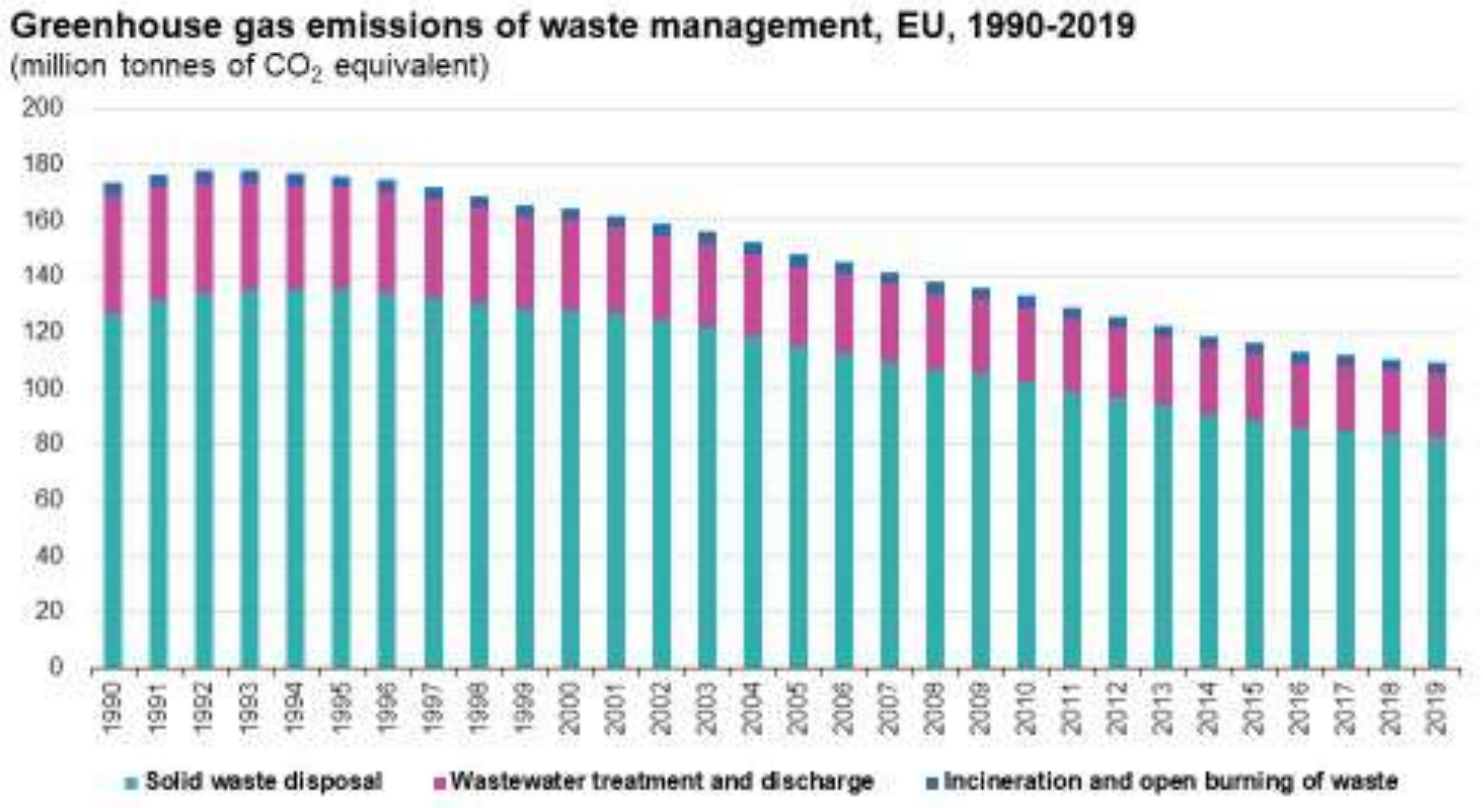
Waste Management System and GHGs Emissions

Source: https://wedocs.unep.org/handle/20.500.11822/8648

4. Global Trends: Few Examples

Global Trends - Europe

- Waste is the *4th* largest source of emissions in the EU → *3%* of total emissions in 2020.
- The amount of waste landfilled fell by *50%* -> because the amount of waste that is ***recycled or composted has tripled*** and ***incineration (with energy recovery) has doubled***
- Emissions from the waste sector decreased by *34 % between 1990-2019*

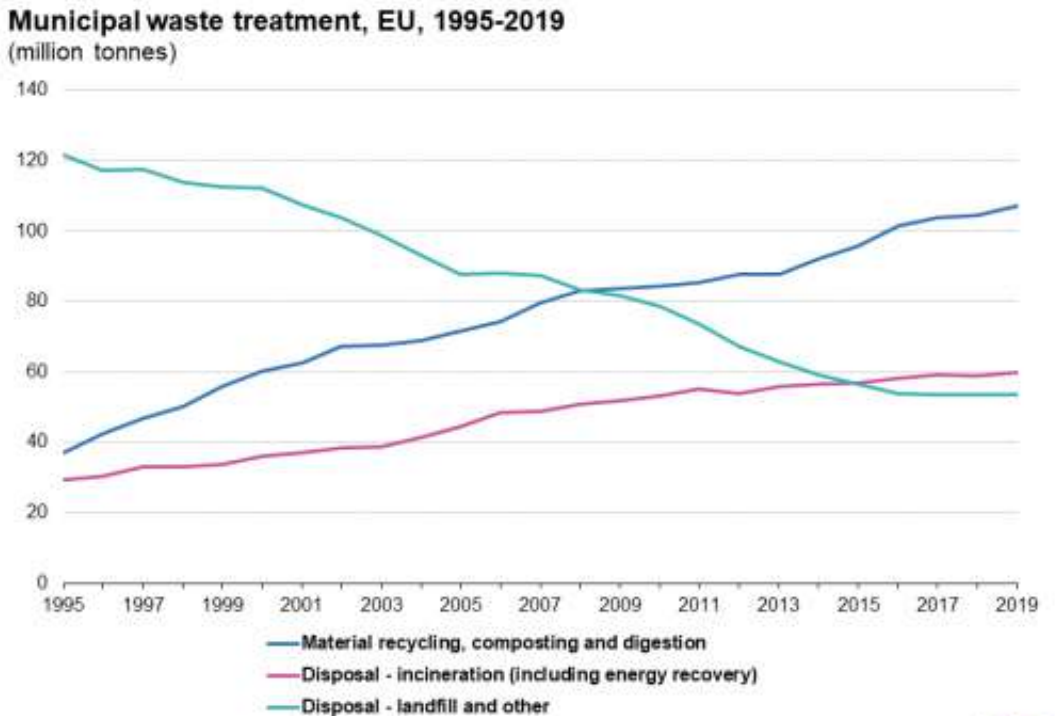


Source: https://ec.europa.eu/eurostat/statistics-explained/index.php?title=Climate_change_-_driving_forces#Emissions_from_waste

Global Trends - Europe

EU legislation changing waste treatment methods & adopting a circular economy approach

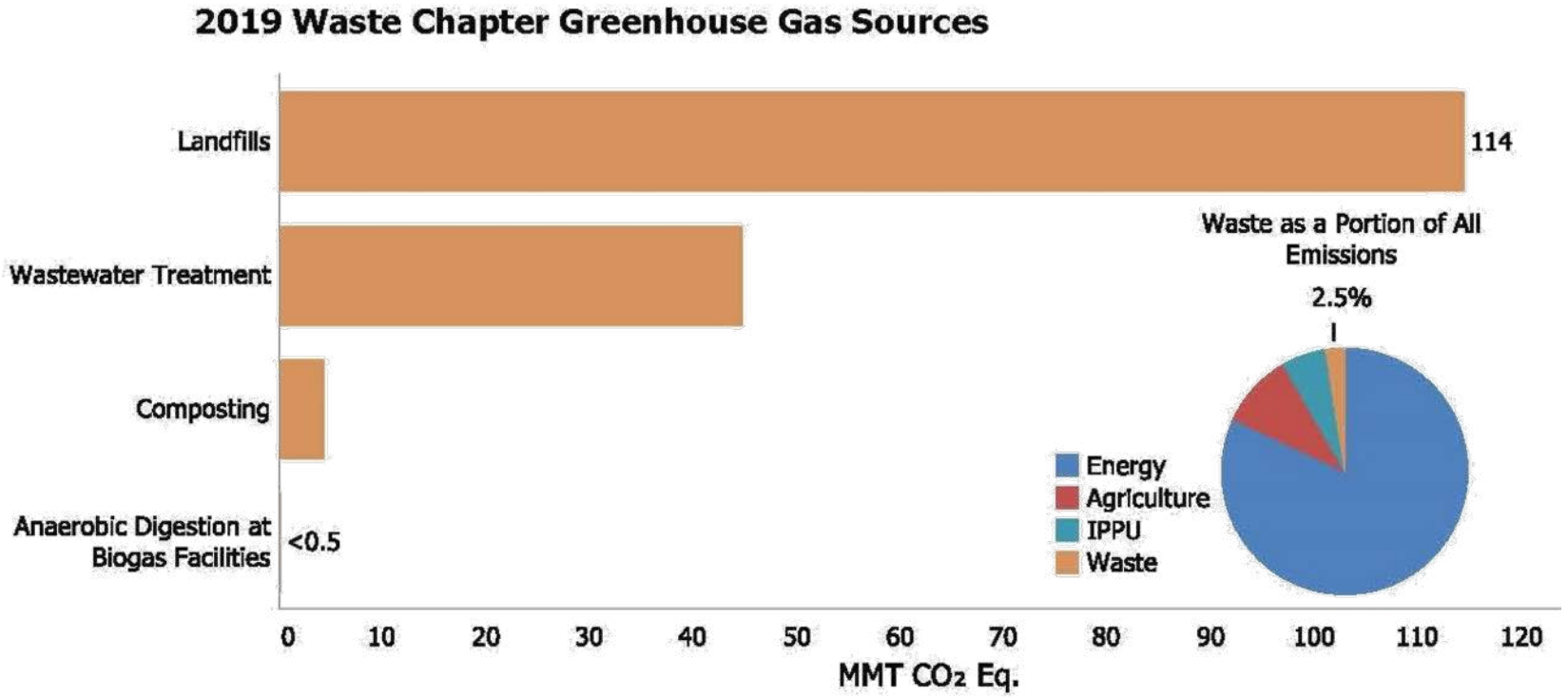
- *Reduction in landfilling in general*
- *Gas recovery mandatory at new sites*
- *More waste being composted & recycled*
- *Reduction in the amount of landfilling*
- *Reduction in the amount of incineration*



Source: https://ec.europa.eu/eurostat/statistics-explained/index.php?title=Climate_change_-_driving_forces#Emissions_from_waste

Global Trends - United States

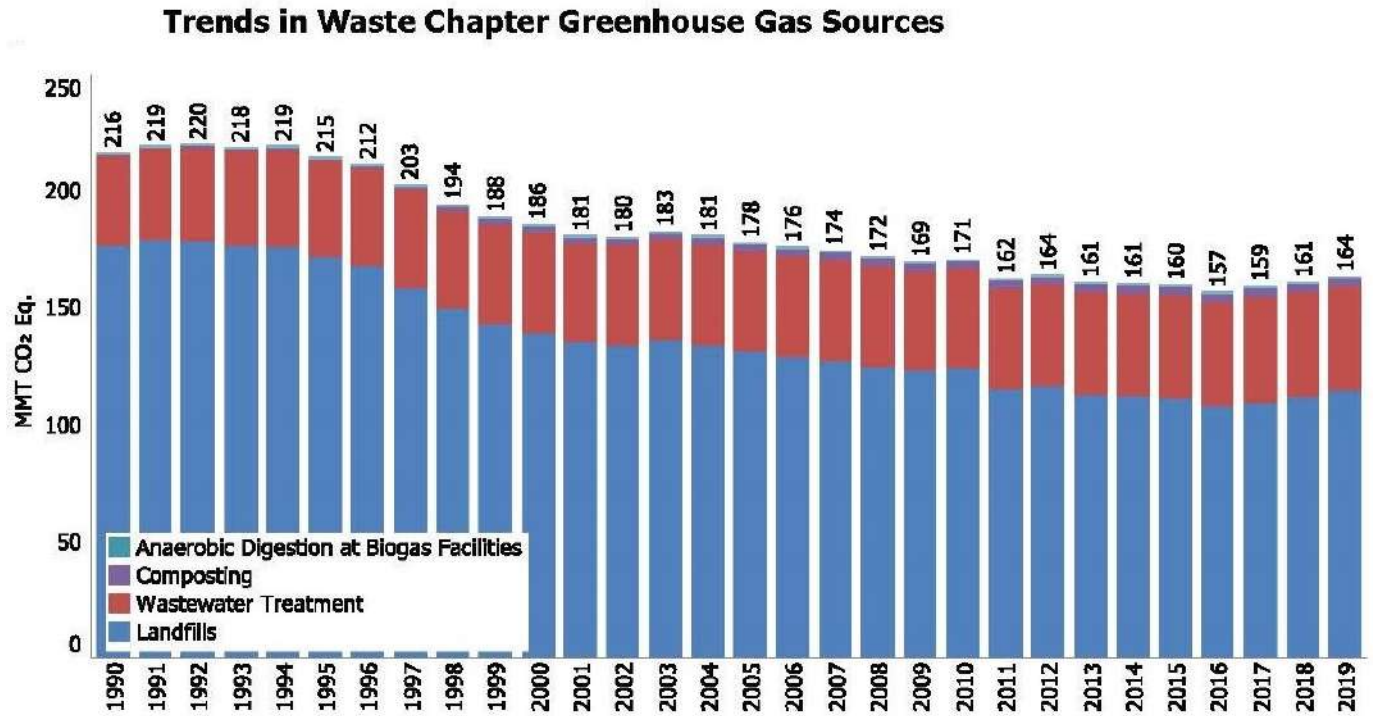
- In 2019, the waste sector in the US generated *2.5%* of total U.S. GHG emissions. ***Over 80%*** of emissions from the waste sector come from ***landfills***
- Landfilling is the most used waste management technique in the United States and ***74%*** of the landfills have landfill ***gas collection and control systems (GCCSs)***



Source: https://www.epa.gov/sites/default/files/2021-04/documents/us-ghg-inventory-2021-chapter-7-waste.pdf?VersionId=skK.lO1zbaYrNwnmUKNiyepctaM_yV3z

Global Trends - United States

- The most prevalent GHG emitted by the Waste Sector is ***CH4***, and landfills are largest emitter of CH4 in this sector (***17.4%*** of total U.S. CH4 emissions in 2019)
- Emissions from the landfills have decreased by ***8%*** from 2011 to 2020. Emissions from industrial waste landfills decreased ***12%*** while emissions from solid waste combustors decreased ***7%*** and wastewater treatment facilities dropped ***10%.***



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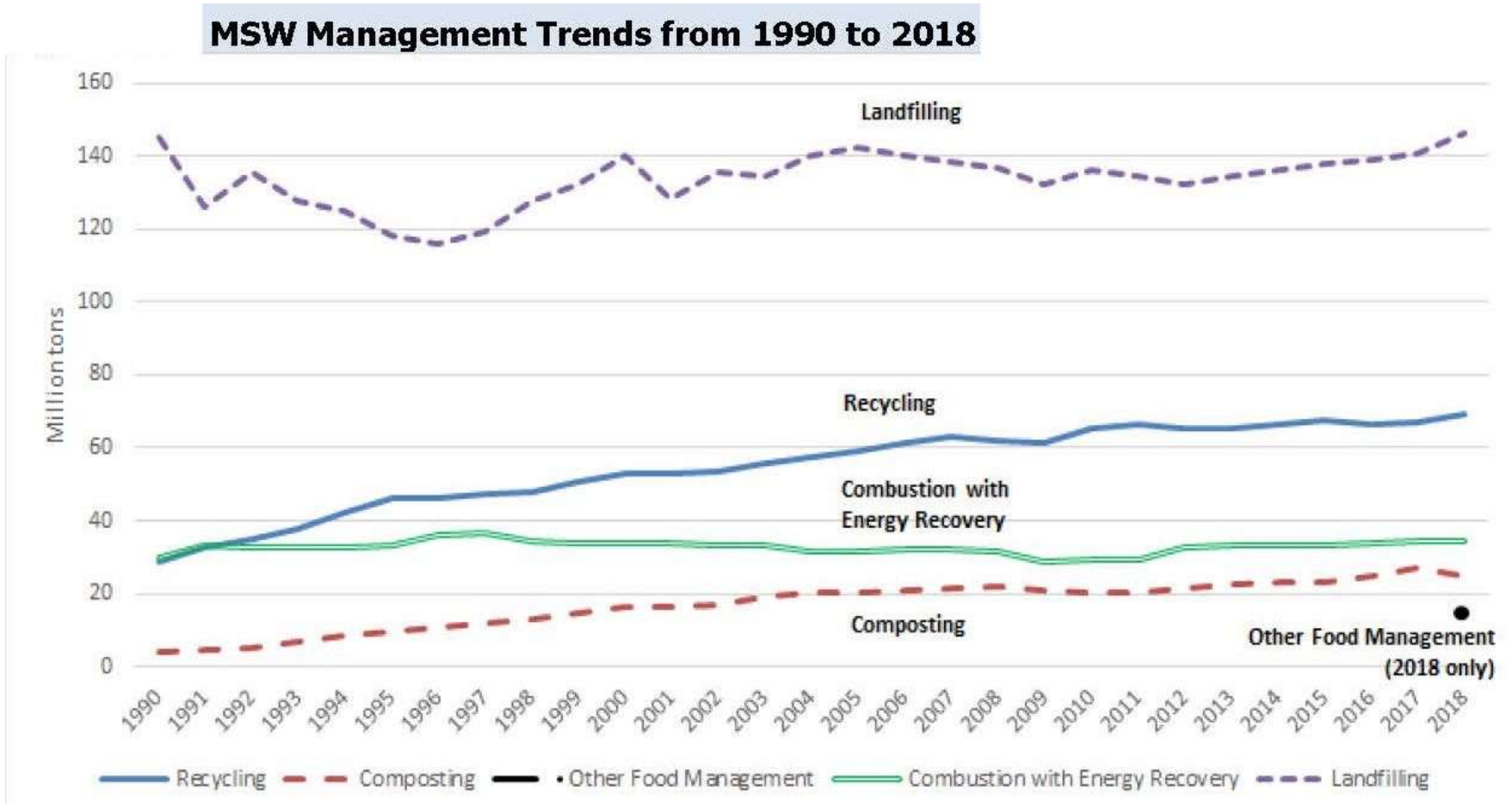
Global Trends - United States



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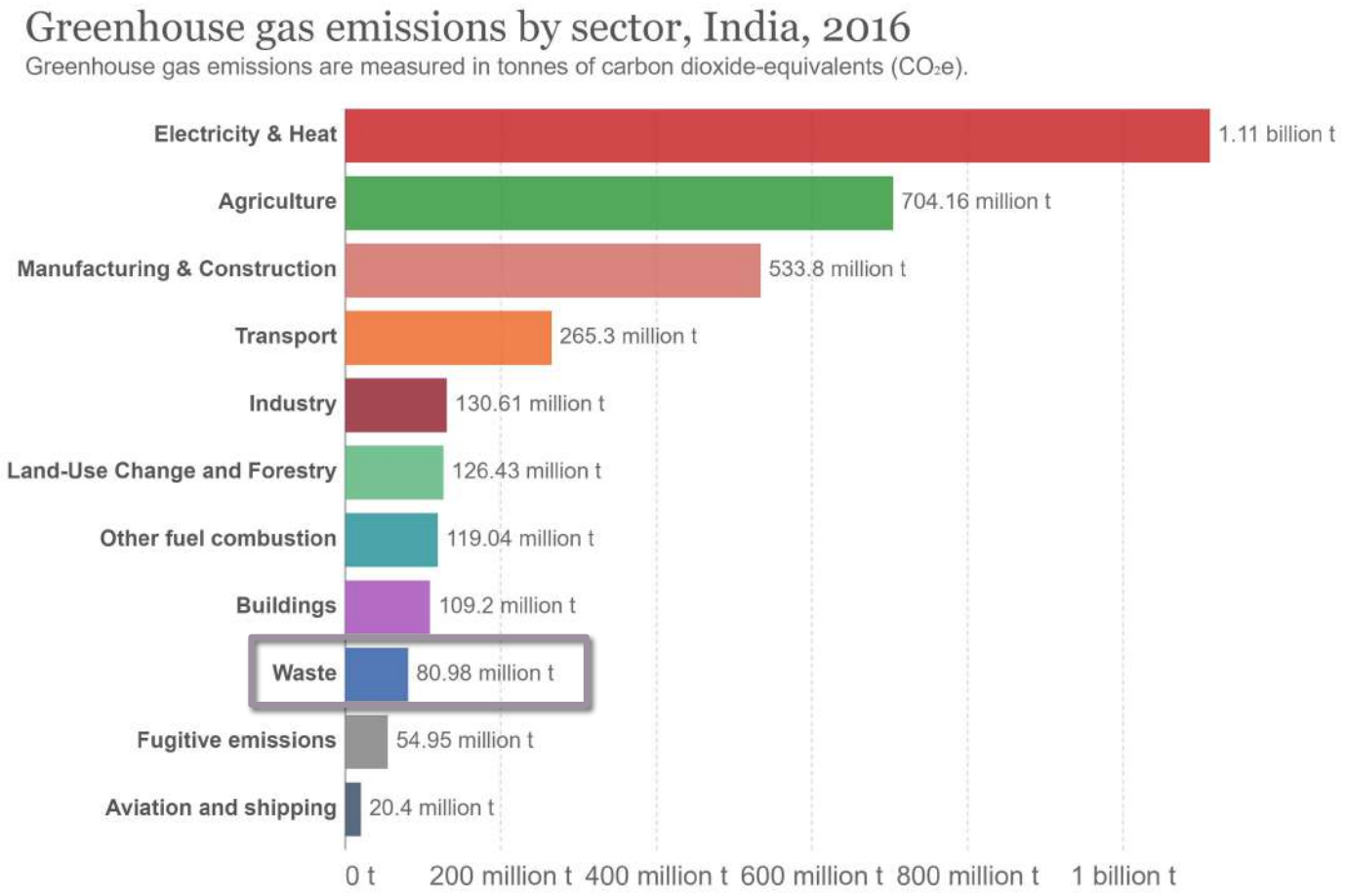
Global Trends - India

- The ***waste sector*** represented ***2.65%*** of GHG emissions in India in 2016.

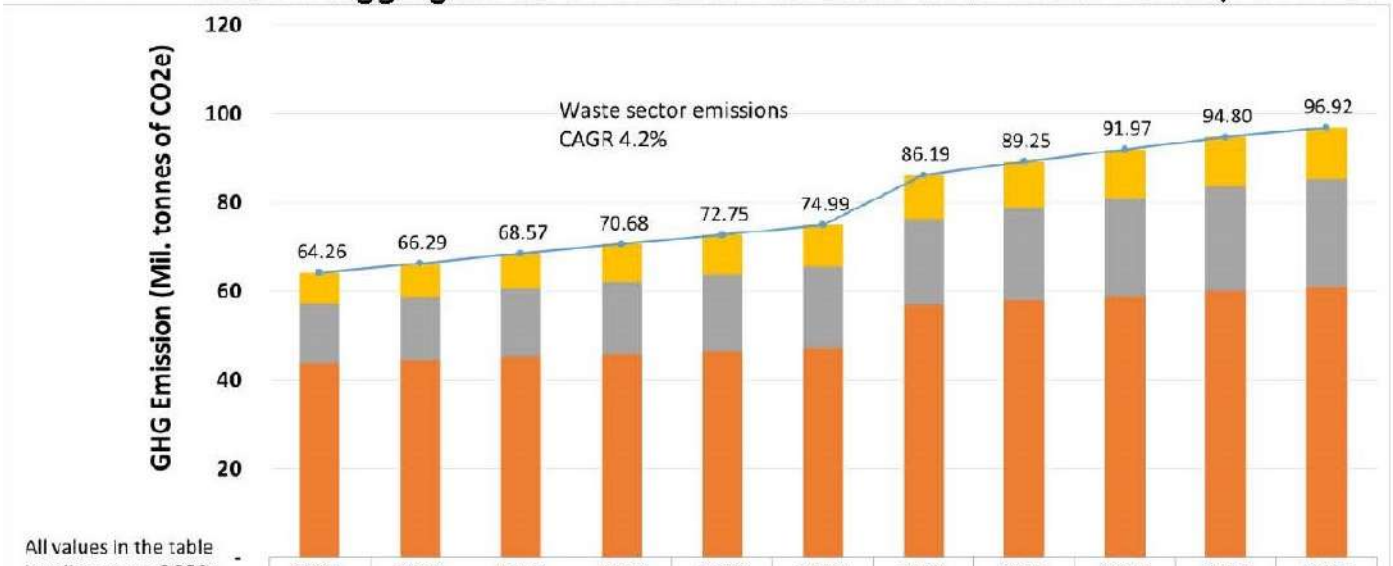


Source: http://www.ghgplatform-india.org/data-and-emissions/waste/GHGPI-PhaseIII-Methodology%20Note-Waste-Sep%202019.pdf
Figure: https://ourworldindata.org/co2/country/india?country=~IND

Global Trends - India

- Waste Sector emissions ***increased by 50%*** in 2015 than in 2005.
- About ***63%*** of the emissions from the waste sector come from domestic wastewater treatment and discharge, ***25%*** from industrial wastewater treatment and discharge, and ***12%*** solid waste disposal in 2015.

Trend of Aggregate GHG Emission Estimates from Waste Sector, 2005-2015

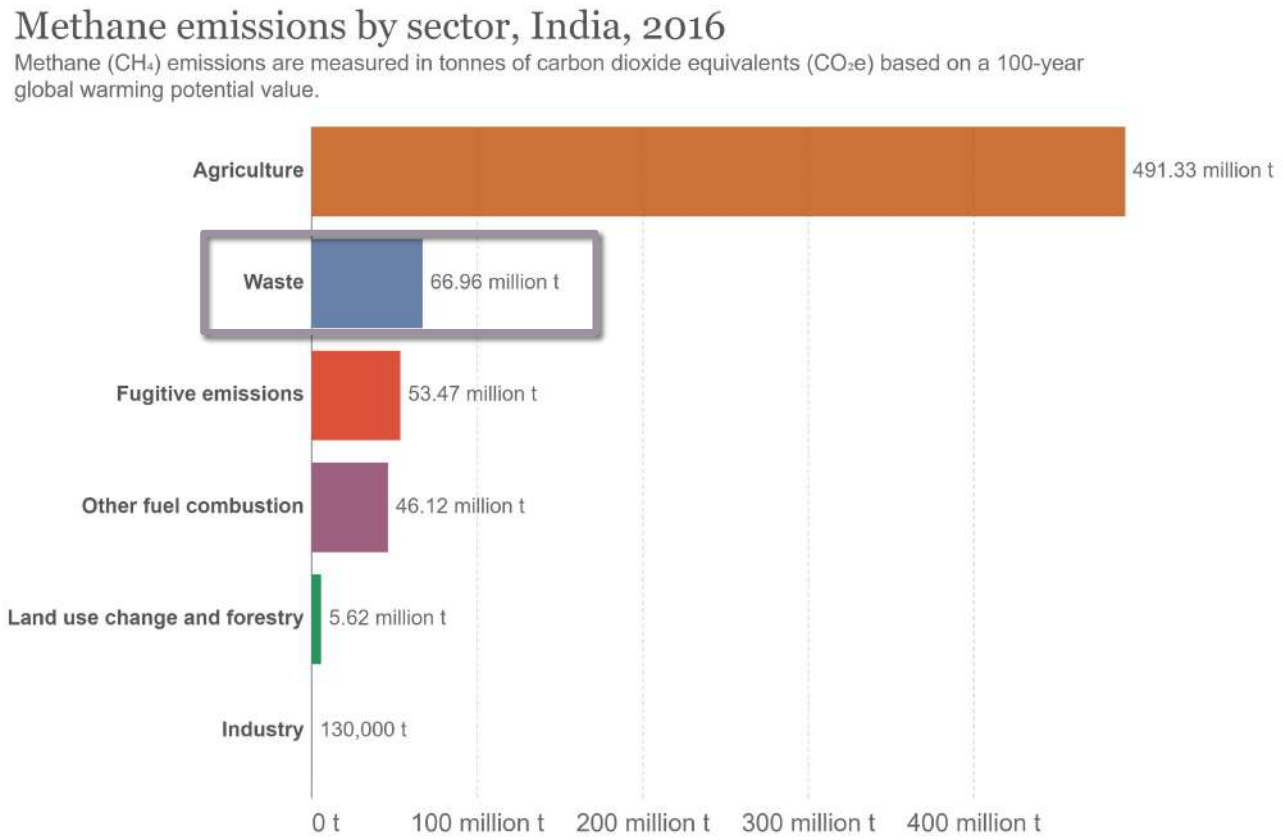


All values in the table in mil. tonnes of CO2e	2005	2006	2007	2008	2009	2010	2011	2012	2013	2014	2015
Solid Waste Disposal	7.05	7.55	8.03	8.51	8.98	9.45	9.92	10.37	10.85	11.26	11.67
Industrial Wastewater	13.39	14.22	15.30	16.26	17.25	18.30	19.38	20.95	22.17	23.50	24.22
Domestic Wastewater	43.82	44.53	45.24	45.90	46.51	47.23	56.90	57.92	58.94	60.04	61.03
Waste sector (total)	64.26	66.29	68.57	70.68	72.75	74.99	86.19	89.25	91.97	94.80	96.92

Source: http://www.ghgplatform-india.org/data-and-emissions/waste/GHGPI-PhaseIII-Methodology%20Note-Waste-Sep%202019.pdf

Global Trends - India

- *CH4* is the primary GHG emitted and accounts for *78.4%* of the waste sector emissions between 2005 and 2015, *21.6%* result from *N20*.
- The waste sector is the second highest sector in CH4 emissions in India.



Source: http://www.ghgplatform-india.org/data-and-emissions/waste/GHGPI-PhaseIII-Methodology%20Note-Waste-Sep%202019.pdf
Figure: https://ourworldindata.org/co2/country/india?country=~IND

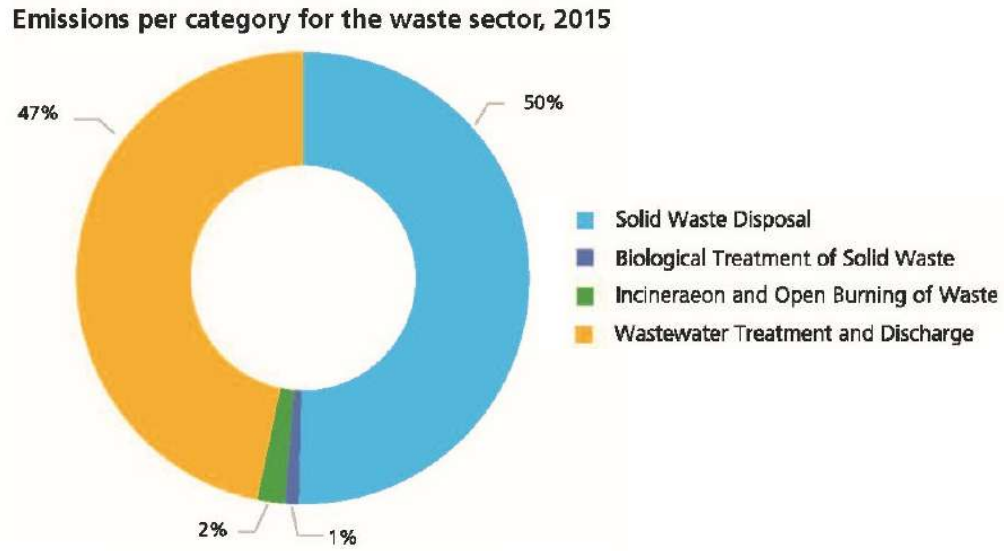
Local Trends - Egypt

- The waste sector was responsible for *8.6%* of Egypt's GHG emissions in 2016.
- <u>According to Egypt's First Biennial Update Report GHG emissions for the waste sector are generated from</u>:

Solid Waste Disposal	Domestic & Industrial Wastewater treatment & discharge	Biological Treatment of Solid Waste	Incineration and Open Burning of Solid Waste

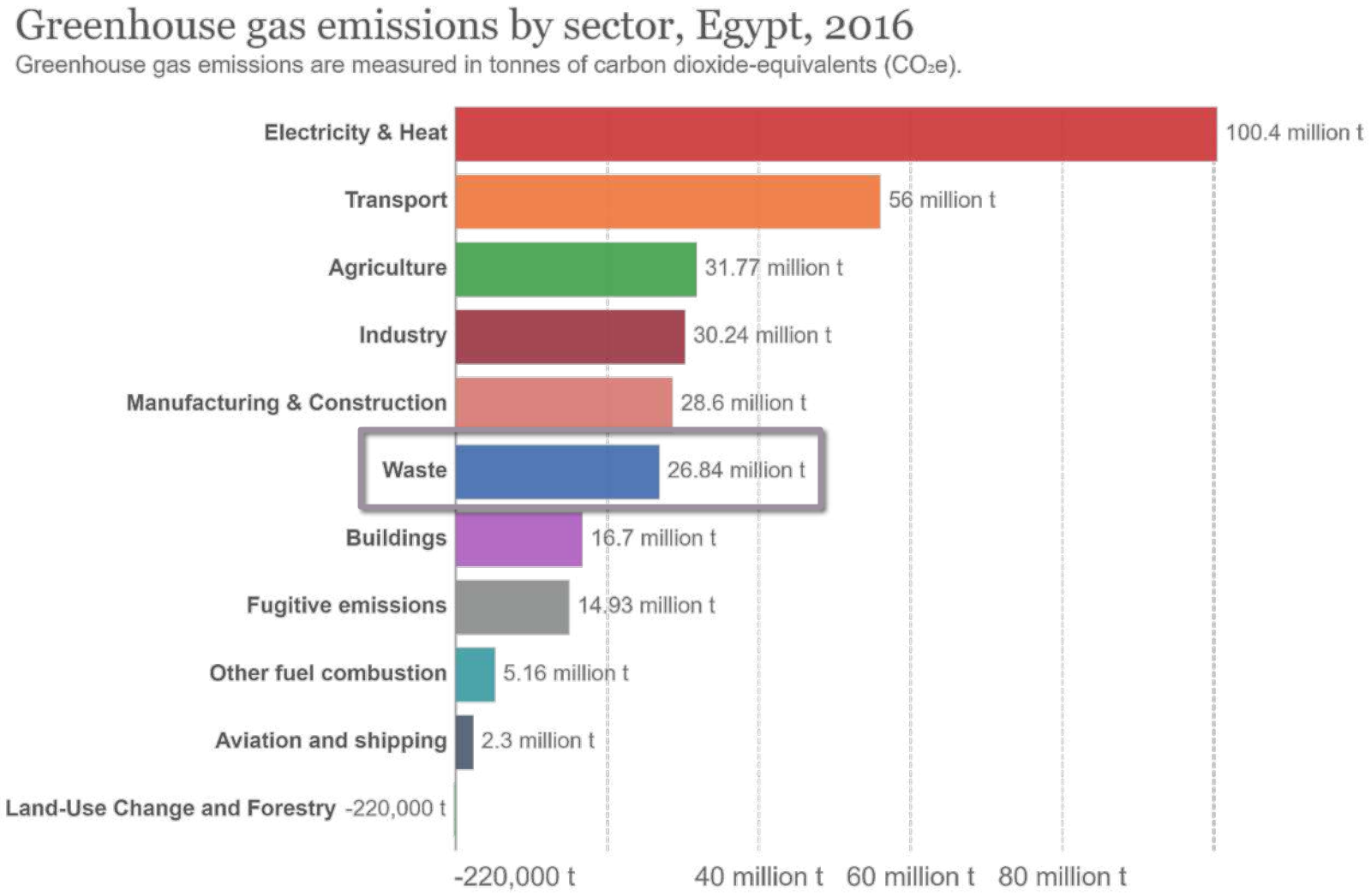
<u>Between 2005-2015</u>

- Solid Waste Disposal contributed between *50%-53%* of waste sector GHG emissions
- Domestic and Industrial Wastewater Treatment and Discharge contributed between *44% and 47%*
- Both constituting about *97%* of waste sector GHG emissions.



Source: https://unfccc.int/sites/default/files/resource/BUR%20Egypt%20EN.pdf

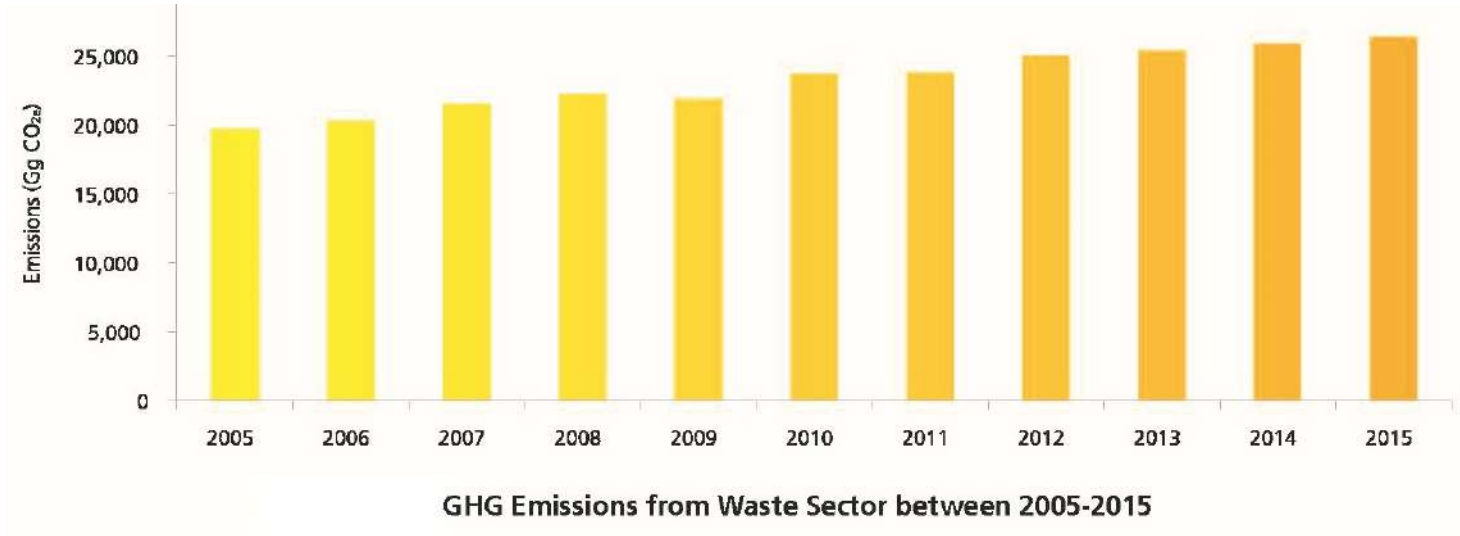
Local Trends - Egypt



Source: https://ourworldindata.org/co2/country/egypt

Local Trends - Egypt

- Total waste sector emissions in 2015 are ***34%*** higher than 2005.



GHG Emissions from Waste Sector between 2005-2015

- Between 2005-2015, GHG emissions increased for all components of the waste sector as follows:

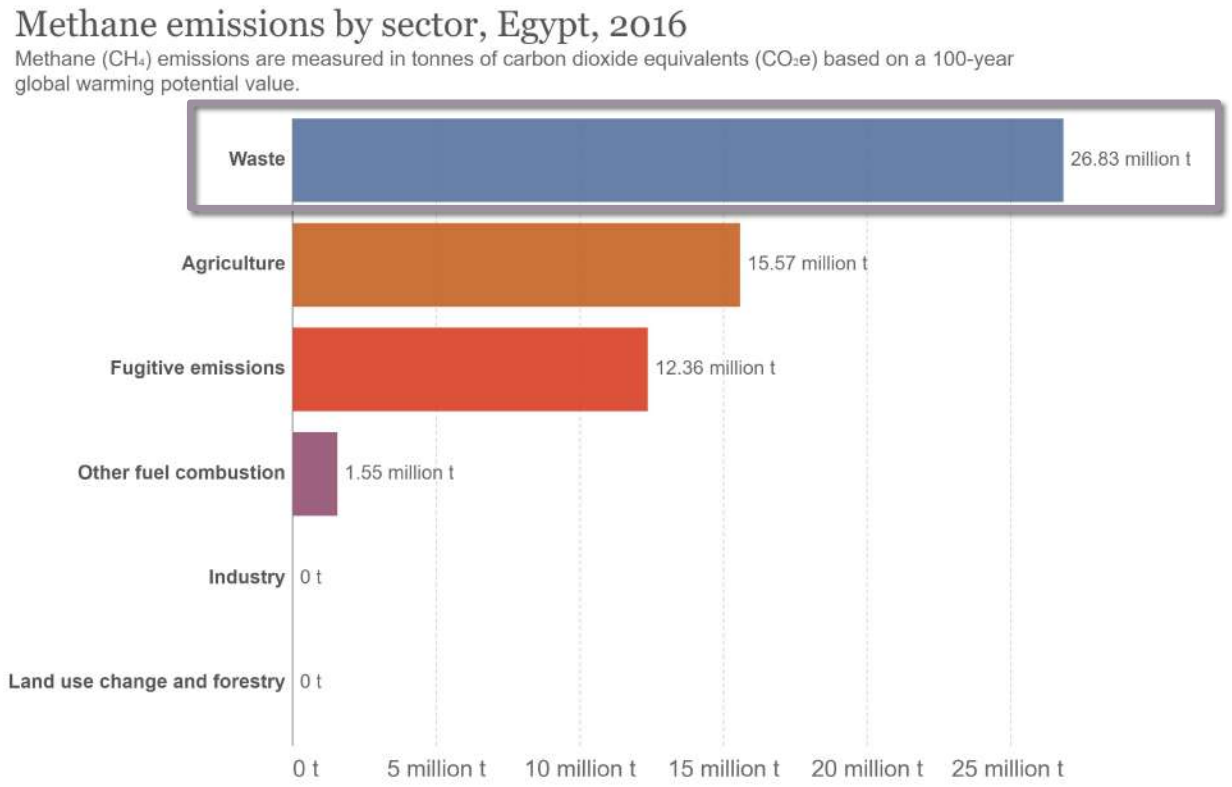
23%	24%	26%	37%	600%
Open burning of waste	Solid waste disposal sites	SW Biological treatment (Composting)	Wastewater treatment & discharge	Medical Waste Incineration

- Emissions from medical waste incineration grew by more than 600% due to improvements in collection systems and increased number of incinerators.

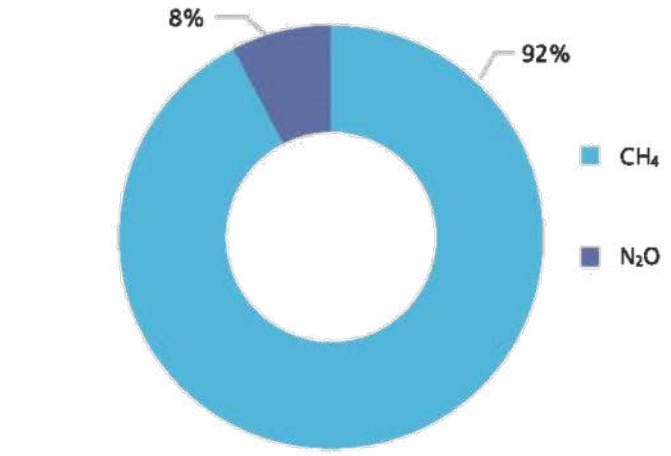
Source: https://unfccc.int/sites/default/files/resource/BUR%20Egypt%20EN.pdf

Local Trends - Egypt

- *CH4* emissions from the waste sector are the highest among all sectors and they account for more than *92%* of overall waste sector GHG emissions.
- *N2O* follows with *7.7%*, while CO2 emissions account for less than *0.2%.*



Source: https://ourworldindata.org/co2/country/egypt

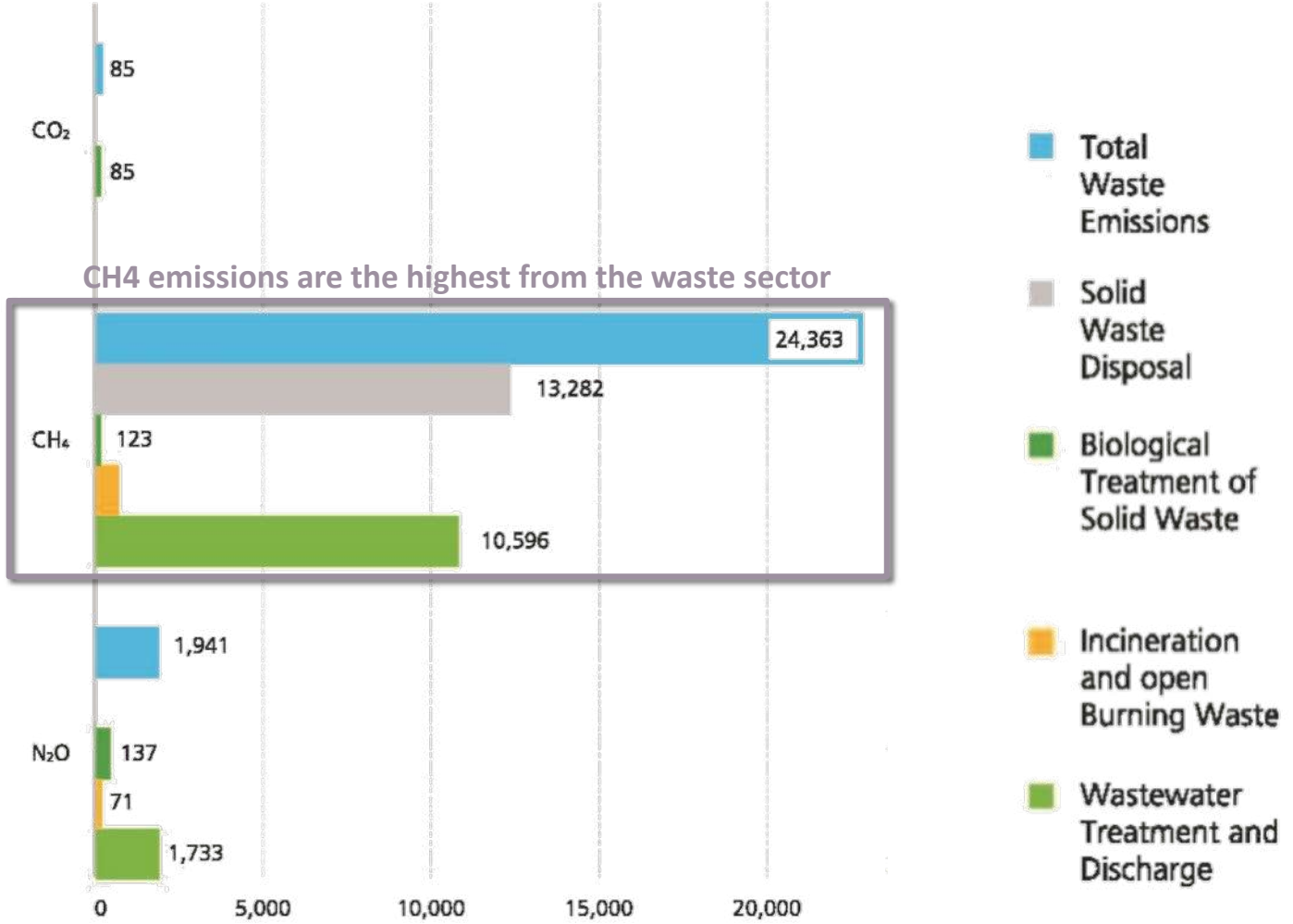


Emissions per gas for the waste sector, 2015

Source: https://unfccc.int/sites/default/files/resource/BUR%20Egypt%20EN.pdf

Local Trends - Egypt

Main waste sector categories contribution to the total waste sector emissions 2015 (Gg CO2e)

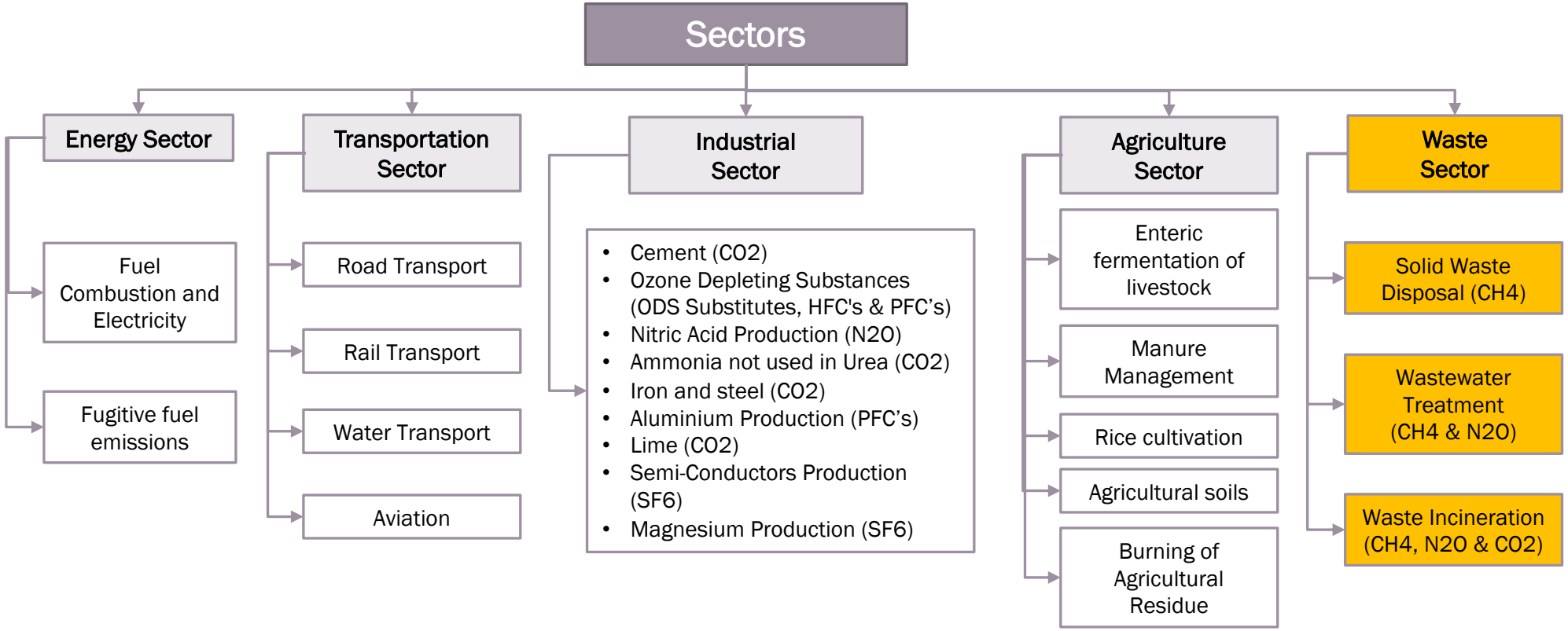


Source: https://unfccc.int/sites/default/files/resource/BUR%20Egypt%20EN.pdf

Local Trends - Egypt

GHGs emissions inventory was reported for Egypt twice. First in the National Inventory Report to National Communication 3 in 2005, and second in the First Biennial Update Report in 2018 which covered the duration from 2005-2015 and was based on the updated IPCC 2006 guidelines.

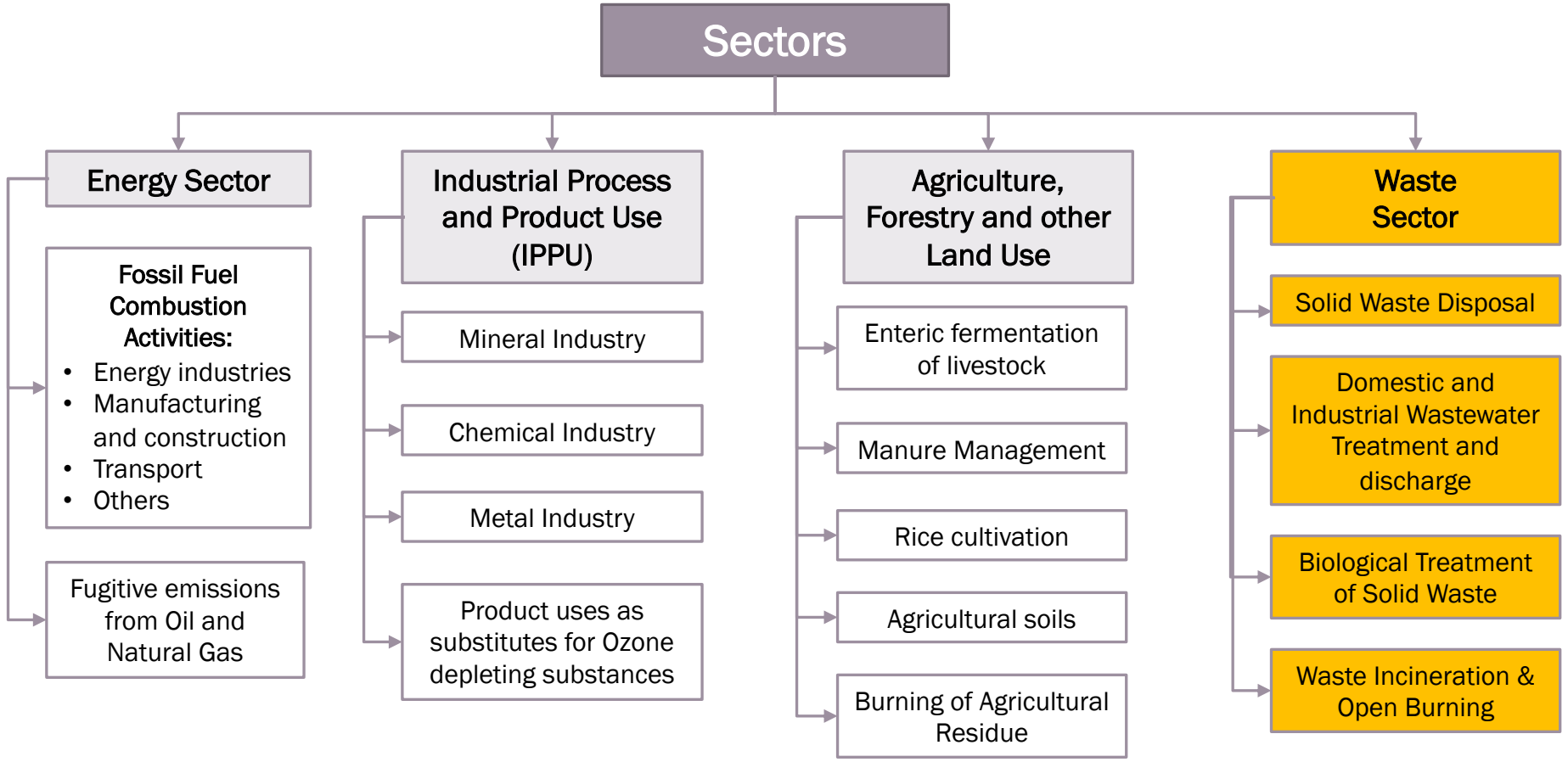
Egypt's National Inventory Report (NIR) to National Communication (NC) 3 - 2005



Source: https://unfccc.int/sites/default/files/resource/GHGI%20chapter%20.pdf

Local Trends - Egypt

Egypt's First Biennial Update Report (2018) – GHGs Inventory from 2005-2015



Source: https://unfccc.int/sites/default/files/resource/BUR%20Egypt%20EN.pdf

5. Strategies and Policies: Mitigation and Adaptation

Mitigation Strategies and Policies - 1

Strategies through which the solid waste sector can reduce its GHG emissions can be summarized as follows:

- ***Source reduction:*** Significant emission reduction gains are achievable through source reduction, mainly for paper product wastes. This should be encouraged for the public and the manufacturers.
- ***Recycling:*** reduces the amount of waste sent to landfills and consequently GHGs emissions. Moreover, the reduction of raw materials that need to be processed, and the energy required for processing decreases GHGs.
- ***Composting:*** reduces GHG emissions through the conversion of rapidly decomposing matter to CO2 opposed to CH4 that will result from sending waste to landfills. Also, composting diverts the waste from landfill sites and produces useful and cost effective by-products.
- ***Landfill gas (LFG) collection techniques:*** collecting and capturing LFG as a source of renewable energy is very attractive and useful techniques that should be encouraged

Source: https://link.springer.com/book/10.1007/978-94-007-1591-2

Mitigation Strategies and Policies - 2

Reducing and recycling solid waste can help to curb GHGs emissions in four important ways:

1. ***Reduced emissions from energy consumption*** – Goods manufactured using recycled materials are less energy intensive. Reusing items (i.e. water bottles) saves even more energy by eliminating the need to manufacture disposable goods.
2. ***Reduced emissions from incinerators*** – Recycling and reuse of materials diverts what would otherwise be burned in waste incinerators, thus mitigating greenhouse gas emissions.
3. ***Reduced methane emissions from landfills*** – Recycling and waste prevention diverts materials away from landfills, which produce large amounts of methane through the decomposition process.
4. ***Increased storage of carbon in trees*** – Trees sequester (absorb and store) carbon dioxide from the atmosphere. By recycling paper, we can help to keep more trees in the ground, which in turn can help to re-stabilize the climate system.

Source: http://www7.nau.edu/itep/main/tcc/docs/resources/om_CCMitigationSolidWaste_021215.pdf

Mitigation Strategies and Policies - 3

- Generation of GHGs from waste is affected by policies which promote waste-to-energy, cleaner waste disposal methods and waste minimization.
- In developed economies waste management policies are integrated with climate policies.

Examples:

Waste Hierarchy as per the EU Waste Framework Directive

Source: https://ec.europa.eu/environment/topics/waste-and-recycling/waste-framework-directive_en

- EU Waste Framework Directive (2008/98/EC)
- EU Legislative Landfill directive (Council Directive 1999/31/EC)
- EU Council Directives (89/369/EEC and 89/429/EEC) were implemented in 1989 to control certain emissions commencing from waste incinerators
- England Directive on Packaging and Packaging Waste (94/62/ EEC)
- US, Clean Air Act (CAA) Amendments/New Source Performance Standards (NSPS) regulates landfill CH4 emissions

Source: https://www.researchgate.net/publication/320333765_An_Insight_to_Atmospheric_Pollution-_Improper_Waste_Management_and_Climate_Change_Nexus/link/5b1d6664a6fdcca67b69094b/download

Adaptation Policies and Actions - 1

Examples of Solid Waste Management Adaptation -Related Actions by Project Cycle Stage

Project Cycle Stage	Adaptation Actions
Scope	• Identify solid waste-related development goals important to the country, community, or sector you are working with. • Identify inputs and enabling conditions necessary to achieving those goals. • Consider the impacts of climate and non-climate stressors on those inputs.
Assess	• Assess climate threats, vulnerabilities, and impacts to solid waste collection, processing, and storage to understand adaption needs • Evaluate climate-related risks in light of all existing risks to solid waste.

Source: https://www.climatelinks.org/resources/addressing-climate-change-impacts-infrastructure-preparing-change-solid-waste-management

Adaptation Policies and Actions - 2

	Adaptation Actions (Examples)		
Design **Planning** **Policy Changes** **Project Development**	**Accommodate/Manage** • Properly site landfills away from floodplains, wetlands, or areas with high water tables. • Site landfills away from drinking water supplies. • Develop sites large enough to accommodate projected population growth and corresponding waste generation. • Design sites with sorting, recycling, and composting facilities to reduce waste storage needs.	**Project/Harden** • Update design standards to elevate and strengthen containment walls to accommodate future sea level rise and high winds. • Design water catchment systems that can keep pace with projected rainfall patterns. • Update equipment design standards to increase efficiency and reduce maintenance costs in changing climate, particularly for complex, HVAC-dependent equipment.	**Retreat/Relocate** • Plan for secure landfill closure and/or relocation. • Plan for extreme event evacuation.

Source: https://www.climatelinks.org/resources/addressing-climate-change-impacts-infrastructure-preparing-change-solid-waste-management

Adaptation Policies and Actions - 3

	Adaptation Actions (Examples)		
Implement & Manage Construction Operation Maintenance Program Activities	Accommodate/Manage • Increase financial and technical resources for more frequent maintenance and repairs. • Train waste sorters and educate the public about separating recyclable and compostable materials from other waste. • Maintain collection vehicles to minimize disruptions due to mechanical failures.	Project/Harden • Prevent erosion of landfill slopes, covers, and roads into and around landfills. • Maintain storm water catchment systems to ensure proper function.	Retreat/Relocate • Cover threatened landfills and develop new sites in more secure locations.
Evaluate & Adjust	• Regularly inspect the integrity of water catchment systems and containment wall, particularly following extreme rain or storm events. • Continue to monitor landfills for groundwater contamination and cover erosion.		

Source: https://www.climatelinks.org/resources/addressing-climate-change-impacts-infrastructure-preparing-change-solid-waste-management

Adaptation Policies and Actions - 4

Examples of climate change adaptation measures integrated in waste management systems:

Extreme weather events

- Frequent collection at scheduled times (based on extreme weather forecasts) reduces risk of waste bags sitting at the curbside for too long and being carried away by heavy rainfall or heavy wind.
- Frequent collection is possible when shorter routes are designed making use of multiple decentralised transfer stations.
- Covered collection trucks and waste containers to prevent waste from drifting away with wind.
- Disposal sites must be compacted each day to force waste disposed to settle, preventing deadly landfill slides (most dangerous for communities living off waste salvaged in or around dump sites).
- Emergency recovery plans in place and up to date to cover a full range of projected weather events.
- Landfill leachate collection system planned with enough capacity for heavy rainfall events.
- Extreme weather events generate a lot of waste from single use emergency equipment (water bottles, tents, plastic sheets, etc). Adapt these materials to be biodegradable or easily recyclable.
- Extreme weather events often generate immense amounts of debris waste from buildings as well as other destroyed materials and landscapes. Establishing a disaster waste management plan helps prepare cities for these extreme waste loads and better plan for recycling materials.

Drought

- Diverting organic waste from landfill through segregated organics collection contributes to preventing landfill fire outbursts.
- Fire-safety structures for landfills, including periodical cover with dry material

Source: https://www.c40knowledgehub.org/s/article/Reducing-climate-change-impacts-on-waste-systems?language=en_US

Adaptation Policies and Actions - 5

Sea level rise

- Ensure the location of new waste disposal sites - historically close to rivers - is not vulnerable to sea level rise projected over the lifetime of the site

Extreme heat

- Decentralised organic waste treatment plants (such as composting and anaerobic digestion) to reduce transporting distances, increase organic waste recovery and reduce risk of dumpsite fire.
- Decentralised waste transfer stations to allow for smaller waste collection vehicles and shorter trips for each worker, especially when the city relies on a labour-intensive system.
- Implement frequent organic waste segregate collection, distributing food waste caddies (reduces odours, pest and insects from rapidly degrading material) and promoting home composting.
- Scheduled collection of waste in a 2 hour buffer from the scheduled time of collection to avoid insects, pests (as well as risk of waste bags being carried away by extreme events).
- Protected and well aerated sorting facilities for resource salvagers/waste pickers to sort waste.
- Install water fountains across the city to reduce consumption of disposable bottles

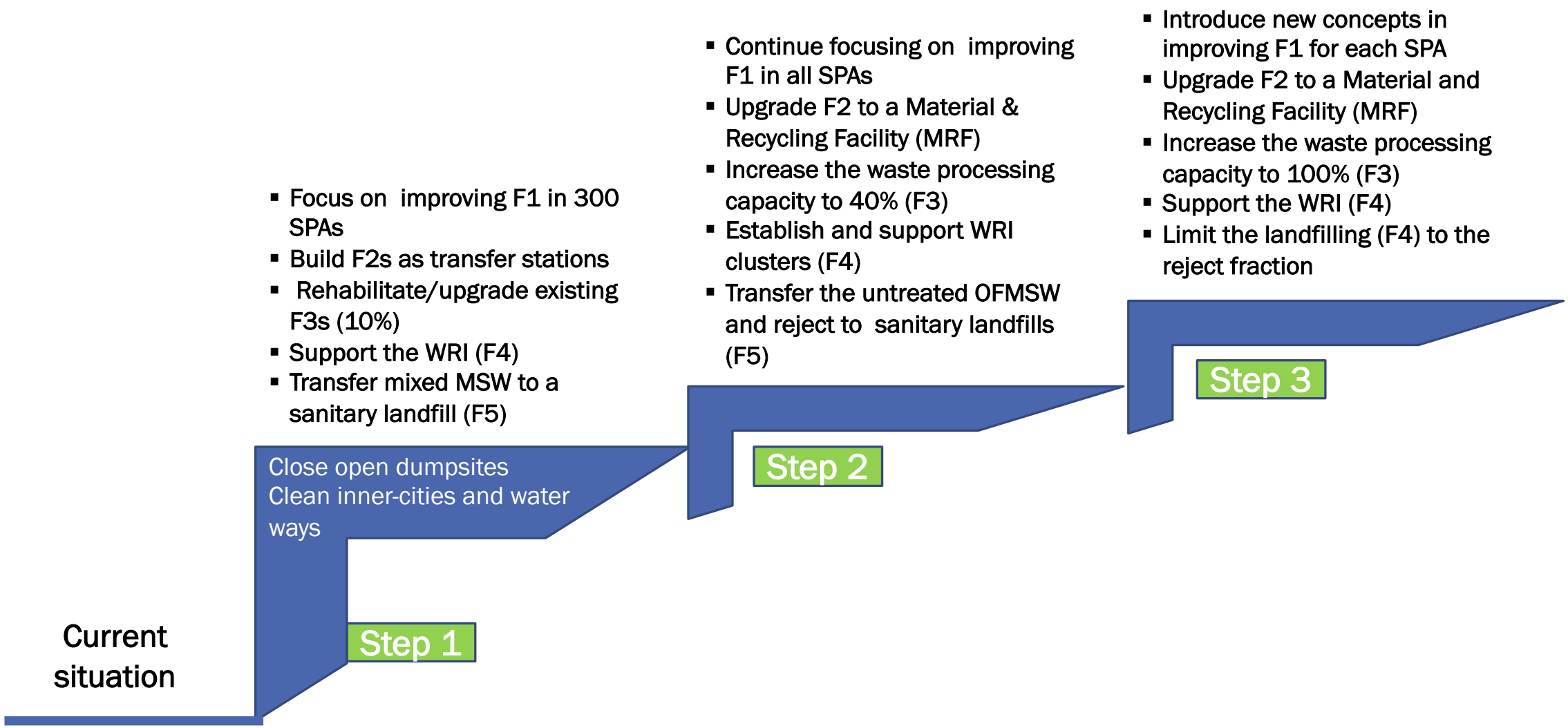
Flooding

- Prevent waste blocking the drainage system
- Ensure landfill has more than one access route and effective drainage systems.
- Ensure waste transfer stations, disposal sites and storage areas are elevated and safe from floods,
- Develop adaptation plans for established sites located in flood areas.
- Aerated elevated or closed curbside collection containers.
- Adopt a post-flood action plan: floods will carry large quantities of waste that will end up in the open once the water level lowers down; plan to quickly collect it and divert as much as possible.

Source: https://www.c40knowledgehub.org/s/article/Reducing-climate-change-impacts-on-waste-systems?language=en_US

6. Proposed Mitigation Approach under Local Conditions

Resources Recovery Ladder (RRL)



- Focus on improving F1 in 300 SPAs
- Build F2s as transfer stations
- Rehabilitate/upgrade existing F3s (10%)
- Support the WRI (F4)
- Transfer mixed MSW to a sanitary landfill (F5)

- Continue focusing on improving F1 in all SPAs
- Upgrade F2 to a Material & Recycling Facility (MRF)
- Increase the waste processing capacity to 40% (F3)
- Establish and support WRI clusters (F4)
- Transfer the untreated OFMSW and reject to sanitary landfills (F5)

- Introduce new concepts in improving F1 for each SPA
- Upgrade F2 to a Material and Recycling Facility (MRF)
- Increase the waste processing capacity to 100% (F3)
- Support the WRI (F4)
- Limit the landfilling (F4) to the reject fraction

Resources Recovery Ladder (RRL)

Initiate the following interventions:
- Provide technical and financial support to the informal sector
- Introduce measures to lower waste generation rate
- Introduce separation at-source

Engage Community

Current situation

Step 1

SP P 1

- Focus on improving F1 in 300 SPAs
- Build F2s as transfer stations
- Rehabilitate/upgrade existing F3s (10%)
- Support the WRI (F4)
- Transfer mixed MSW to a sanitary landfill (F5)

Step 2

SP P 2

- Continue focusing on improving F1 in all SPAs
- Upgrade F2 to a Material & Recycling Facility (MRF)
- Increase the waste processing capacity to 40% (F3)
- Establish and support WRI clusters (F4)
- Transfer the untreated OFMSW and reject to sanitary landfills (F5)

Step 3

SP P3

- Introduce new concepts in improving F1 for each SPA
- Upgrade F2 to a Material and Recycling Facility (MRF)
- Increase the waste processing capacity to 100% (F3)
- Support the WRI (F4)
- Limit the landfilling (F4) to the reject fraction

Improve energy efficiency and minimize emissions

Resources Recovery Ladder (RRL)

Initiate the following interventions:
- Support SMEs/entrepreneurs in the waste recycling sector
- Initiate extended producer responsibility

Engage Community

SP P 1

- Focus on improving F1 in 300 SPAs
- Build F2s as transfer stations
- Rehabilitate/upgrade existing F3s (10%)
- Support the WRI (F4)
- Transfer mixed MSW to a sanitary landfill (F5)

SP P 2

- Continue focusing on improving F1 in all SPAs
- Upgrade F2 to a Material & Recycling Facility (MRF)
- Increase the waste processing capacity to 40% (F3)
- Establish and support WRI clusters (F4)
- Transfer the untreated OFMSW and reject to sanitary landfills (F5)

SP P3

- Introduce new concepts in improving F1 for each SPA
- Upgrade F2 to a Material and Recycling Facility (MRF)
- Increase the waste processing capacity to 100% (F3)
- Support the WRI (F4)
- Limit the landfilling (F4) to the reject fraction

Current situation

Step 1

Step 2

Step 3

Improve energy efficiency and minimize emissions

7. Concluding Remarks

Concluding Remarks

1. The topic of the presentation is covered with wealth of literature tackling almost every aspect of related science and technology
2. We need to develop an Egyptian position paper on waste and climate change taking into consideration the recent developments in the sector

ANNEX: ROCK

Review of Current Knowledge (RoCK)

Egypt Information

No.	Document Title	Date	Description
1	Egypt Biennial Update Report (BUR). BUR 1 (English) (Arabic)	2018	The Government of Egypt has prepared this first Biennial Update Report (BUR) for submission to the UNFCCC in 2018 as part of its obligation as a party to the UNFCCC.
2	Egypt Third National Communication under the UNFCCC	2016	Egypt's Third National Communication, funded by the Global Environment Facility (GEF) through the UNDP Egypt, was submitted as part of Egypt's obligations as a party to the UNFCCC. Chapter 2 of the document includes Egypt National Greenhouse Gas Inventory.
3	Egypt Second National Communication under the UNFCCC	2010	Egypt's Second National Communication was submitted as part of Egypt's obligations as a party to the UNFCCC. Chapter 2 of the document includes Egypt National Greenhouse Gas Inventory.
4	Initial National Communication on Climate Change	1999	Egypt's Initial National Communication document was submitted as part of Egypt's obligations as a party to the UNFCCC. The document includes national circumstances, GHG inventory, expected impacts of climate change, mitigation and adaptation options, and any further steps taken by Egypt to deal with climate change. Also it presents the research gaps and needs related to the science of climate, impacts of climate change, increasing awareness , and policy oriented research.

Egypt Information

No.	Document Title	Date	Description
5	Greenhouse Gas Emissions in Egypt. USAID	2015	This document presents Egypt's GHG profile in 2012 and the emissions from each economical sector.
6	Egypt's 2021 Voluntary National Review	2021	This report focuses on monitoring the implementation of Egypt's 2030 Agenda.
7	Egyptian Intended Nationally Determined Contributions	2015	In accordance with Decisions 1/CP.19 and 1/CP.20, Egypt submitted its report on the Intended Nationally Determined Contributions (INDCs) towards achieving the objectives of the UNFCCC. The report provides information which enhances clarity, transparency, and understanding of Egypt's INDC.

Review of Current Knowledge (RoCK)

Climate Change and the Waste Sector

No.	Document Title	Date	Description
1	Solid Waste Management Options and their Impacts on Climate Change and Human Health	2012	This book chapter assess the various robust and cost effective management alternatives, such as landfilling, composting, incineration, recycling, and the use of landfill gas (LFG) as a renewable source of energy. The chapter also addresses the impacts of these management strategies that are reflected on the environment.
2	An Insight to Atmospheric Pollution- Improper Waste Management and Climate Change Nexus	2018	This book chapter attempts to relate the nexus between improper management of municipal solid waste and climate change and to reduce greenhouse gas emissions through proven technologies and existing policies.
3	The Climate Change Mitigation Potential of the Waste Sector	2015	This study presents the greenhouse gas (GHG) mitigation potential of municipal solid waste (MSW) management in OECD countries as well as India and Egypt.
4	Interrelation between Climate Change and Solid Waste	2019	This paper is aimed at reviewing the relationship between solid waste and climate change.
5	Mitigation of global greenhouse gas emissions from waste: conclusions and strategies from the IPCC Fourth Assessment Report.	2008	This paper presents conclusions and strategies from the Intergovernmental Panel on Climate Change (IPCC) Fourth Assessment Report with a focus on mitigation of GHGs from waste.

Climate Change and the Waste Sector

Review of Current Knowledge (RoCK)

No.	Document Title	Date	Description
6	Potential impacts of climate change on waste management	2003	This report starts the process of considering what climate change could mean for municipal waste management and how it could be addressed. The scope of the waste management techniques and activities addressed within the report is focused on the management of municipal and household waste.
7	Solid waste and climate change: Perceptions and possibilities	2009	This paper investigates the impacts of the waste sector on climate change in developing countries.
8	Chapter 10 – Waste Management (In Climate Change 2007: Mitigation. Contribution of Working Group III to the Fourth Assessment Report of the IPCC	2007	This chapter presents the impact of waste on climate change and the possibilities of mitigation measures.
9	Waste and Climate Change. Global Trends and Strategy Framework. UNEP	2010	This report is intended as a further step in a global dialogue to engage the international waste community, identify the key issues, and create a strategy that will deliver significant climate benefit in the waste sector.
10	IPCC Guidelines for GHGs Inventory for Waste (2006) (Refinement 2019)	2006 2019	This Guidelines provide methodologies for making estimates of national anthropogenic emissions and removals of greenhouse gases from the waste sector.