GHG Emissions: Waste Sector Overview

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Belize

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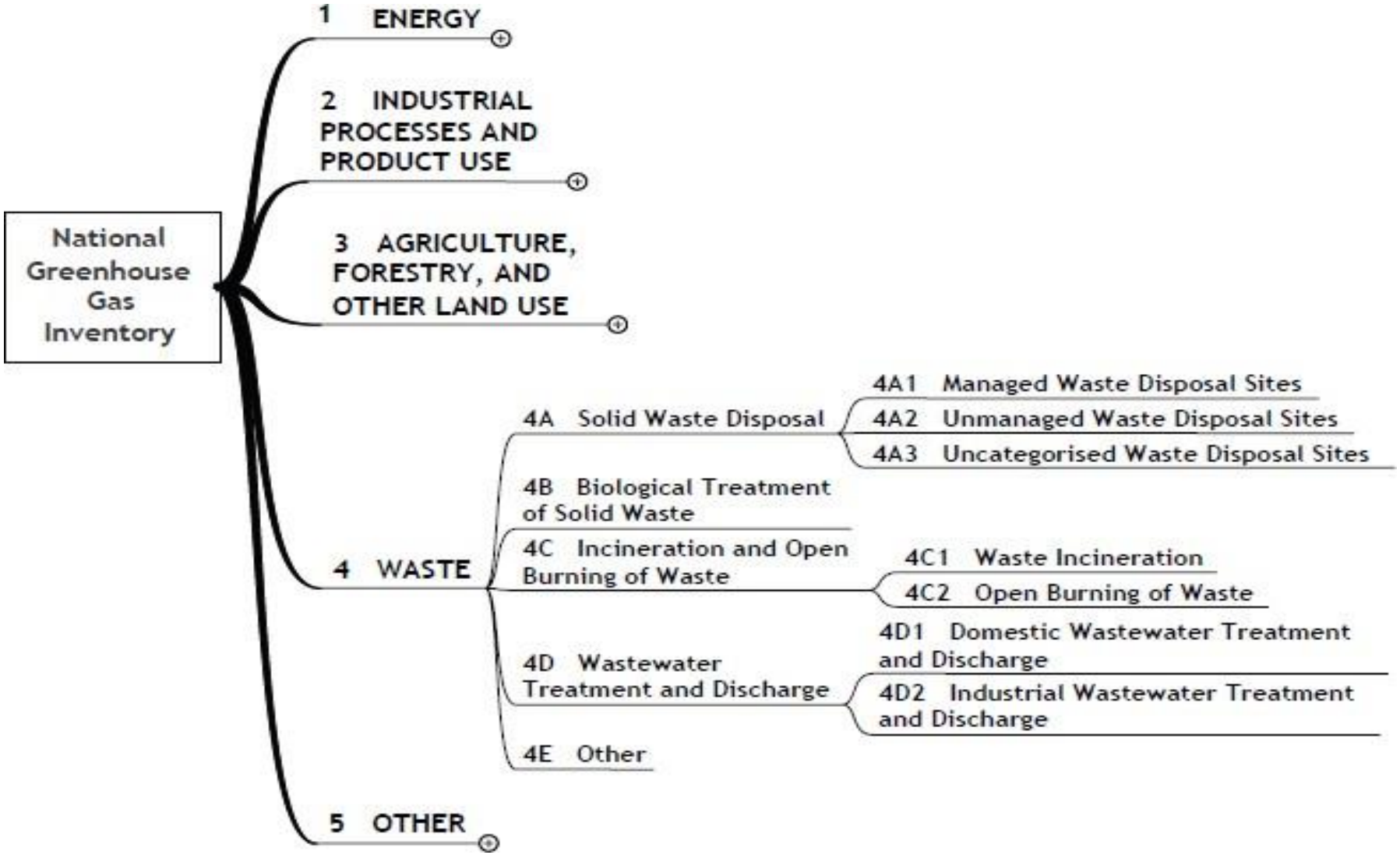
Content

- General Overview of Waste Sector
- Methods for Estimation of Greenhouse Gas Emissions from Waste Sector
  - Solid waste disposal (4A)
  - Incineration and open burning of waste (4C)

Structure of the waste in IPCC 2006 Guidelines



Introduction to the Waste Sector

According to the IPCC, the major GHG emission source categories in the Waste sector are:

- Solid Waste Disposal (SWD)
- Biological Treatment
- Incineration
- Wastewater treatment and Discharge.

Volume 5 of the IPCC guidelines provides methodological guidance for estimation of the categories above.

Introduction

- Volume 5 (Waste) provides methodological guidance for estimation of CO2, CH4 and N2O emissions from following categories:
  - Solid waste disposal (4A)
  - Biological treatment of solid waste (4B)
  - Incineration and open burning of waste (4C)
  - Wastewater treatment and discharge (4D)
- Typically, CH4 emissions from solid waste disposal sites (SWDS) are the largest source in the Waste sector
- Biogenic CO2 emissions are not included in the Waste sector
- All greenhouse gas emissions from **waste-to-energy** should be estimated and **reported under the Energy sector**

Waste Sector - Categories

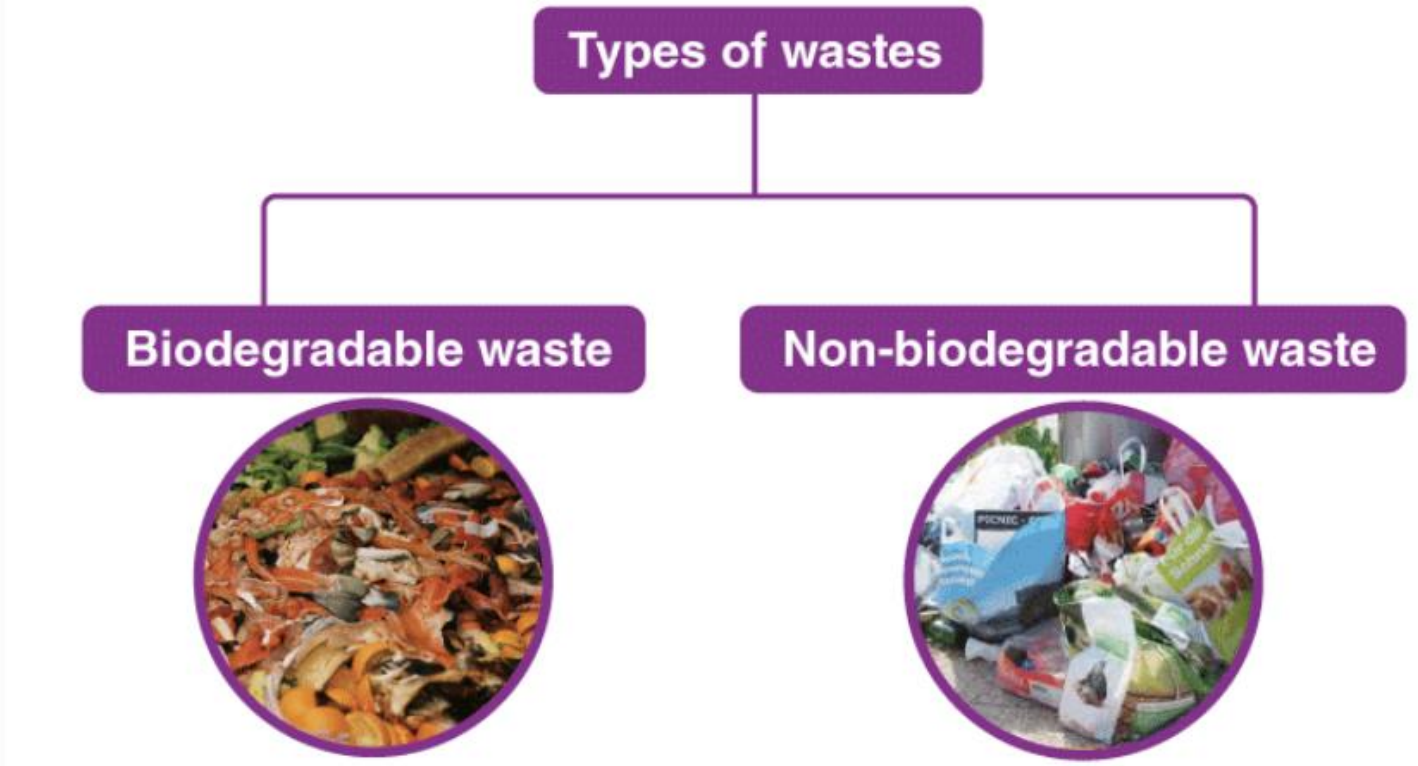
	Sub-categories	GHG reported
Solid Waste Disposal (SWD)	Municipal Solid Waste	CH_4
	Industrial waste	CH_4
Biological Treatment of Solid Waste	Composting	CH_4 N_2O
	Anaerobic Digestion	CH_4 N_2O
	Mechanical-biological treatment	CH_4 N_2O
Incineration and Open Burning of Waste	Waste Incineration	CO_2 (fossil carbon) CH_4 N_2O
	Open Burning of Waste	CO_2 (fossil carbon) CH_4 N_2O
	Incineration of Fossil Liquid Waste	CO_2 (fossil carbon)
Wastewater Treatment and Discharge	Domestic Wastewater Treatment and Discharge	CH_4 Direct N_2O (may be considered a minor source) Indirect N_2O
	Industrial Wastewater Treatment and Discharge	CH_4 Direct N_2O (may be considered a minor source) Indirect N_2O

General overview of waste

Definition of waste:

Unwanted and unusable materials and which is regarded as a substance that is unusable.

Normally, waste are in two types.



What subcategories and GHGs does Belize account for?

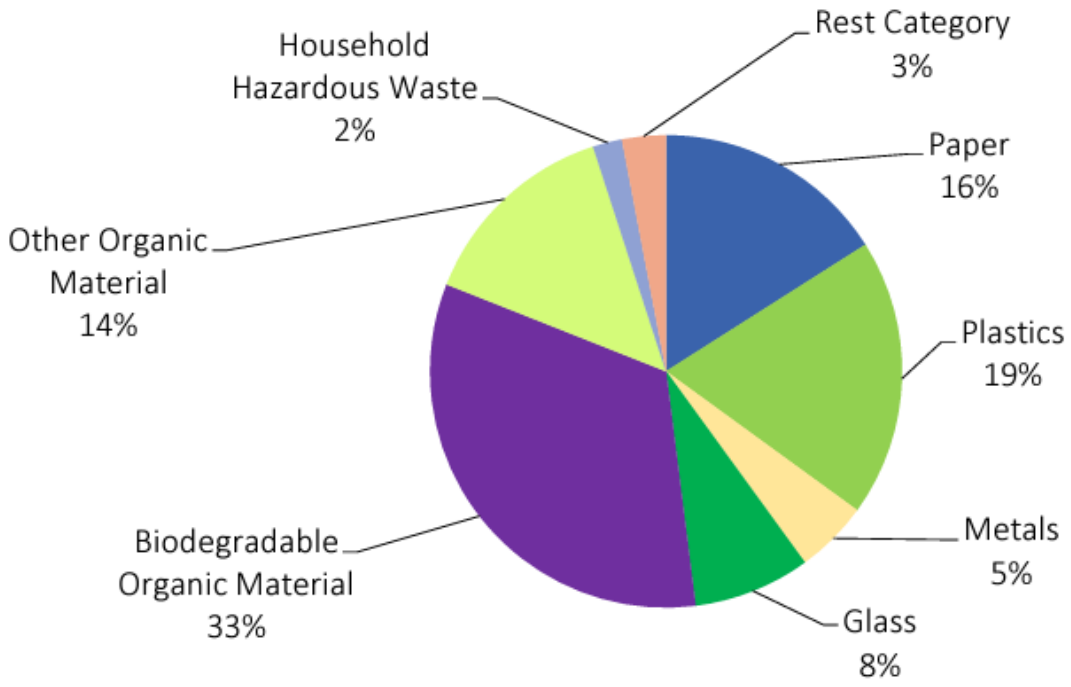
Categories
4 – Waste
4.A – Solid Waste Disposal
4.A.1 – Managed Waste Disposal Sites
4.A.2 – Unmanaged Waste Disposal sites
4.A.3 – Uncategorized Waste Disposal Sites
4.C - Incineration and Open Burning of Waste
4.C.1 – Waste Incineration
4.C.2 – Open Burning of Waste
4.D – Waste treatment and Discharge
4.D.1 – Domestic Wastewater Treatment and Discharge
4.D.2 – Industrial Wastewater Treatment and Discharge
4.E – Other (please specify)

Legislation pertinent to the Waste sector

- Belize Environmental Protection Act, 1992
- Solid Waste Management Authority Act, 1991
- Effluent Limitations Regulations, 1996

Waste Characterization in Belize

Figure 2.31: Solid Waste Composition – Western Corridor



Source: Hydroplan & Solid Waste Management Authority.

This study of the western corridor was used as expert judgment to classify solid waste across the country

*more studies can be made to improve statistics by region

Still better than using default values based on trends in LAC

A person generates around **1.07 kg or 2.36 lbs daily in Belize**

(Hydroplan for Solid Waste Management Authority, May 2011).

Solid Waste Disposal Categories in Belize

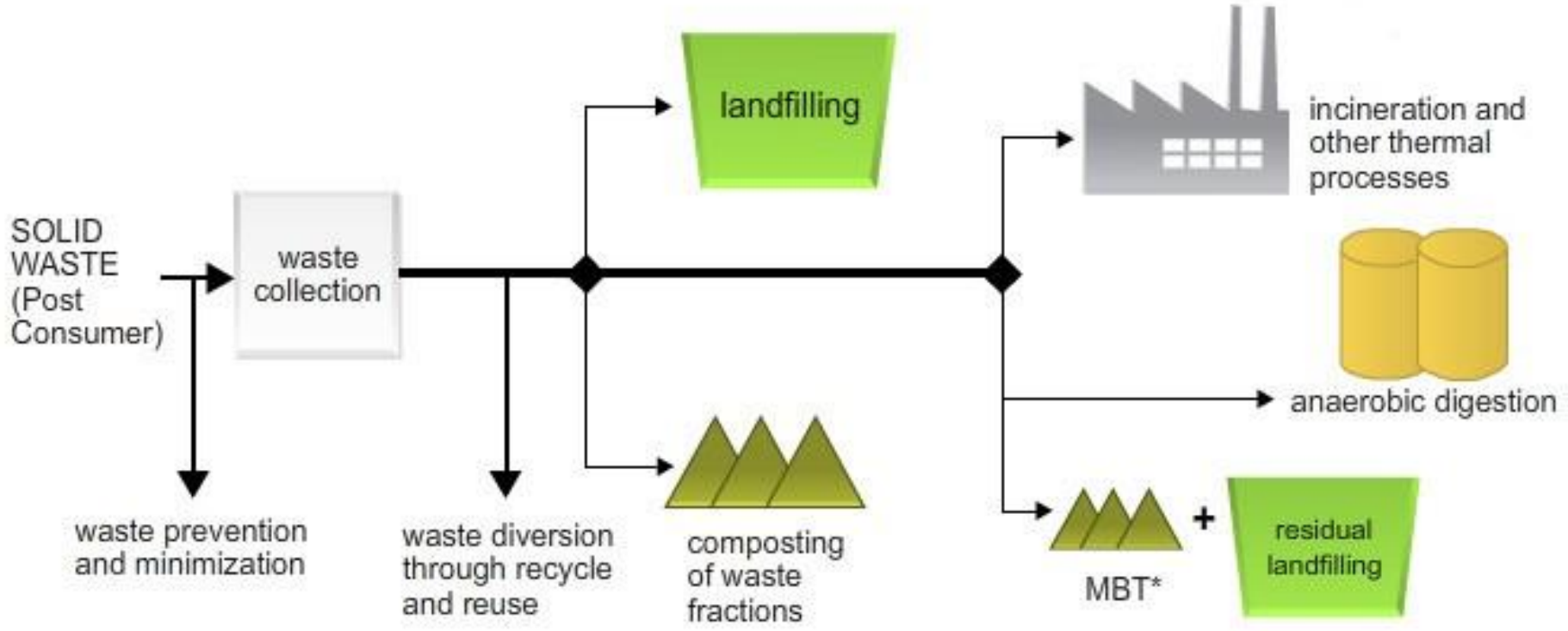
Table 2.27: Summary of Disposal Categories and Relevance to Belize

waste

CATEGORY	DESCRIPTION	BELIZE APPLICATION
Unmanaged Shallow	Unmanaged SWDS not meeting criteria of managed SWDS with depths less than 5 meters	All open dumps and illicit dumps (mostly rural population)
Unmanaged Deep	Unmanaged SWDS not meeting criteria of managed SWDS with heights greater than or equal to 5 meters and with low water table	This definition applied to the Belize City dumps operated up until their closure in 2009, thus relevant for inventory years 1994-2009
Managed Anaerobic	SWDS with controlled placement of waste and with some degree of control, including the control of fires and a degree of cover material	All municipal dump sites, including the one used at Independence and Placentia are classified under this category
Managed-Semi-aerobic	SWDS with controlled placement of waste, permeable cover material, leachate drainage system, etc.	In this case, the National Sanitary Landfill meets most of these criteria, thus the population being served by the National Landfill was estimated for each inventory year. The populations and years when the populations were served by the landfill were considered.

- Only the Belize City dumps (now closed) were categorized as unmanaged deep
- The population with limited or no waste disposal services, primarily in the rural areas, was used for the category of unmanaged shallow.

Solid Waste Pathway



Calculation of National Total Emissions

Waste Sector

Solid waste disposal

$$DOC = \Sigma_i = (DOC_i * W_i)$$

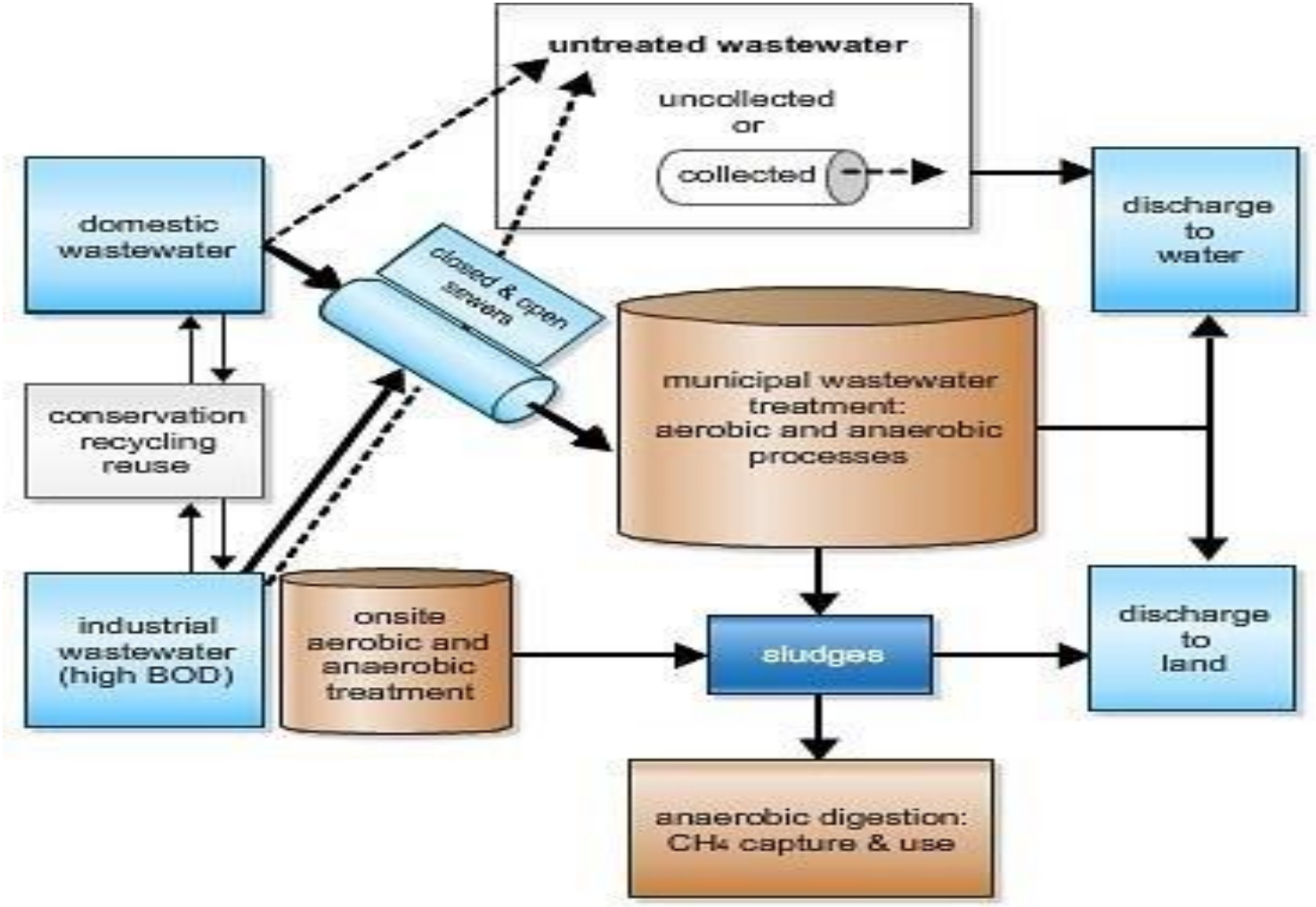
Where,

DOC = fraction of degradable organic carbon in bulk waste, Gg C/Gg waste

DOC_i = fraction of degradable organic carbon in waste type I

W_i = fraction of waste type i by waste category

Wastewater Pathways



Waste - Fundamental Processes

There are many different pathways of waste treatment and disposal. For the GHG emissions that occur- we need to consider these fundamental processes:

- Anaerobic decomposition / digestion
- Nitrification and denitrification
- Incineration / combustion

Anaerobic Decomposition/Digestion

- CH4 is generated when the carbon contained in waste decomposes under anaerobic conditions. This can happen with wastewater, solid waste disposal and biological treatment of waste.

- The process breaks down the biodegradable carbon for energy in the absence of oxygen and produces CH4 , CO2 and other trace gases.

- The process of anaerobic digestion is a natural process used by mankind to treat biodegradable waste and sewage sludge.

Calculation of National Total Emissions

Biological Treatment of Solid Waste

CH4 emissions from biological treatment

$$CH_4 \text{ Emissions} = \Sigma_i = (M_i * EF_i) * 10^{-3} - R$$

Where,

CH4 Emissions = total CH4 emissions in inventory year, Gg CH4

M_i = mass of organic waste treated by biological treatment type i, Gg

EF = emission factor for treatment i, g CH4/kg waste treated

i = composting or anaerobic digestion

R = total amount of CH4 recovered in inventory year, Gg CH4

N2O emissions from biological treatment

$$N_2O \text{ Emissions} = \Sigma_i = (M_i * EF_i) * 10^{-3}$$

Where,

N_2O Emissions = total N2O emissions in inventory year, Gg N2O

M_i = mass of organic waste treated by biological treatment type i, Gg

EF = emission factor for treatment i, g N2O/kg waste treated

i = composting or anaerobic digestion

Nitrification and Denitrification

N_2O emissions occur…

- When nitrogen compounds in waste contribute to nitrification/denitrification at wastewater treatment facilities.

- Where excess nitrogen in wastewater that has been discharged into water bodies drives natural nitrification and denitrification cycles.

- Nitrification occurs in aerobic conditions (with oxygen) and oxidises ammonium (NH4 +) into nitrites & nitrates.

Calculation of National Total Emissions

Wastewater

$$CH_4\ Emissions = \left[\sum_{i,j}\left(U_i \bullet T_{i,j} \bullet EF_j\right)\right](TOW - S) - R$$

Where:

CH_4 Emissions = CH_4 emissions in inventory year, kg CH_4/yr

TOW = total organics in wastewater in inventory year, kg BOD/yr

S = organic component removed as sludge in inventory year, kg BOD/yr

U_i = fraction of population in income group *i* in inventory year, See Table 6.5.

$T_{i,j}$ = degree of utilisation of treatment/discharge pathway or system, *j*, for each income group fraction *i* in inventory year, See Table 6.5.

i = income group: rural, urban high income and urban low income

j = each treatment/discharge pathway or system

EF_j = emission factor, kg CH_4 / kg BOD

R = amount of CH_4 recovered in inventory year, kg CH_4/yr

Total Emission = CH4 Emission x GWP_CH4 + N2O Emission x GWP_N20

N_2O EMISSIONS FROM WASTEWATER EFFLUENT

$$N_2O\ Emissions = N_{EFFLUENT} \bullet EF_{EFFLUENT} \bullet 44/28$$

Where:

N_2O emissions = N_2O emissions in inventory year, kg N_2O/yr

$N_{EFFLUENT}$ = nitrogen in the effluent discharged to aquatic environments, kg N/yr

$EF_{EFFLUENT}$ = emission factor for N_2O emissions from discharged to wastewater, kg N_2O-N/kg N

The factor 44/28 is the conversion of kg N_2O-N into kg N_2O.

TOTAL NITROGEN IN THE EFFLUENT

$$N_{EFFLUENT} = \left(P \bullet Protein \bullet F_{NPR} \bullet F_{NON-CON} \bullet F_{IND-COM}\right) - N_{SLUDGE}$$

Where:

$N_{EFFLUENT}$ = total annual amount of nitrogen in the wastewater effluent, kg N/yr

P = human population

Protein = annual per capita protein consumption, kg/person/yr

F_{NPR} = fraction of nitrogen in protein, default = 0.16, kg N/kg protein

$F_{NON-CON}$ = factor for non-consumed protein added to the wastewater

$F_{IND-COM}$ = factor for industrial and commercial co-discharged protein into the sewer system

N_{SLUDGE} = nitrogen removed with sludge (default = zero), kg N/yr

Incineration/Combustion

- Leads to biogenic and fossil derived CO2 emissions as well as CH4 and N2O emissions.

- Only CO2 from incineration of fossil carbon is considered anthropogenic.

- Biogenic CO2—paper, wood products, food scraps, yard clippings. It is assumed that these is carbon emissions are accounted for under Land Use Change sector.

Accounting Complexities (1)

Watch for possible overlap between the **Waste sector** and…

Energy sector:

- Emissions from the combustion of waste with energy recovery are reported in the Energy sector. However, only CO_2 resulting from combustion of fossil origin carbon are included in national totals. Emissions from combustion of biogenic carbon is reported as a memo line.

Accounting Complexities (2)

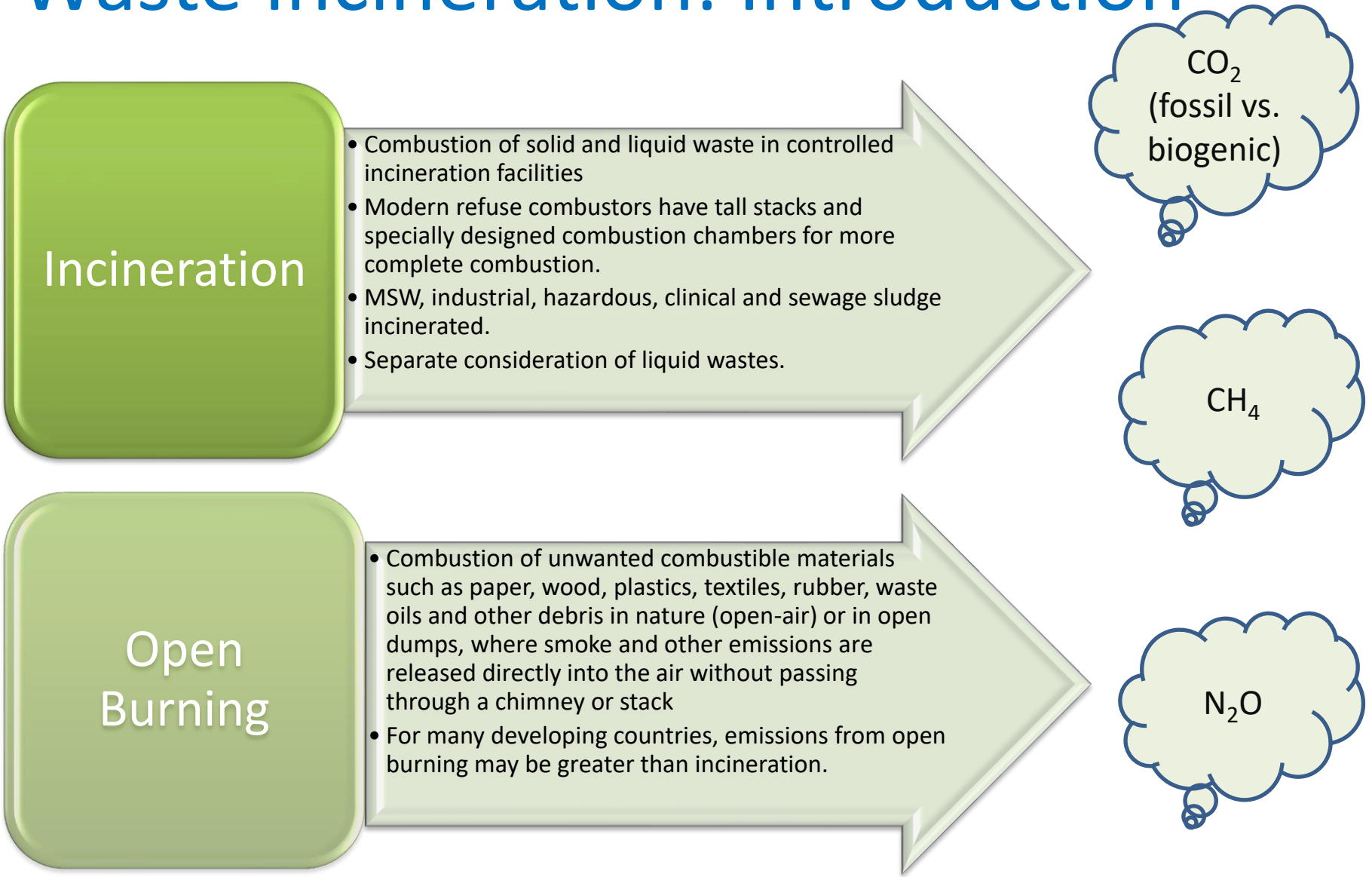
Watch for possible overlap between the **Waste sector** and…

Agriculture sector:

- Anaerobic digestion and composting of manure in Agriculture sector.
- Manure burned without energy recovery reported in error under waste.
- Compost/sludge applied to cropland and grassland reported under agriculture, to other land uses under those land uses.

Incineration and Open Burning of Waste

Waste Incineration: Introduction

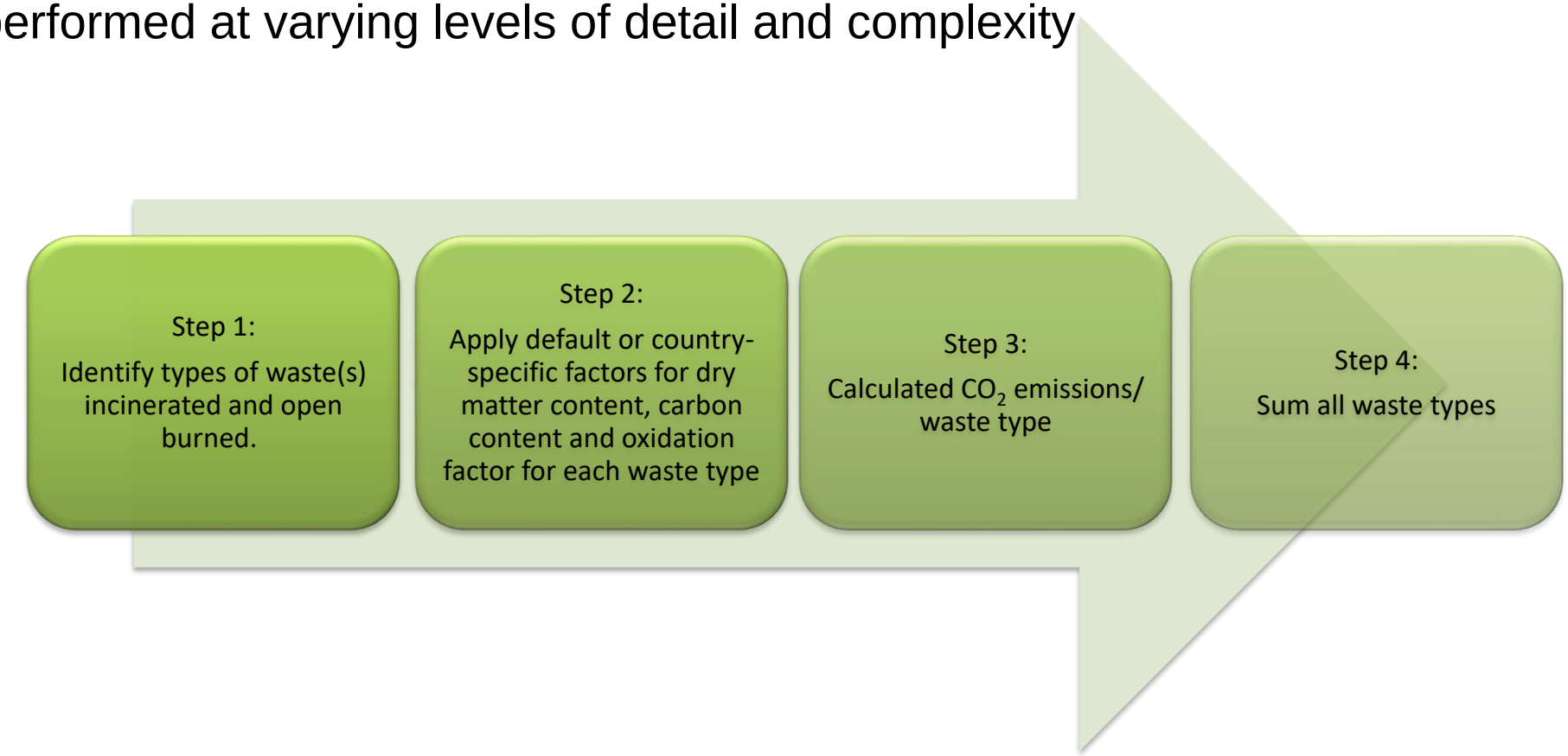


Waste Incineration: Relationship to Other Sectors

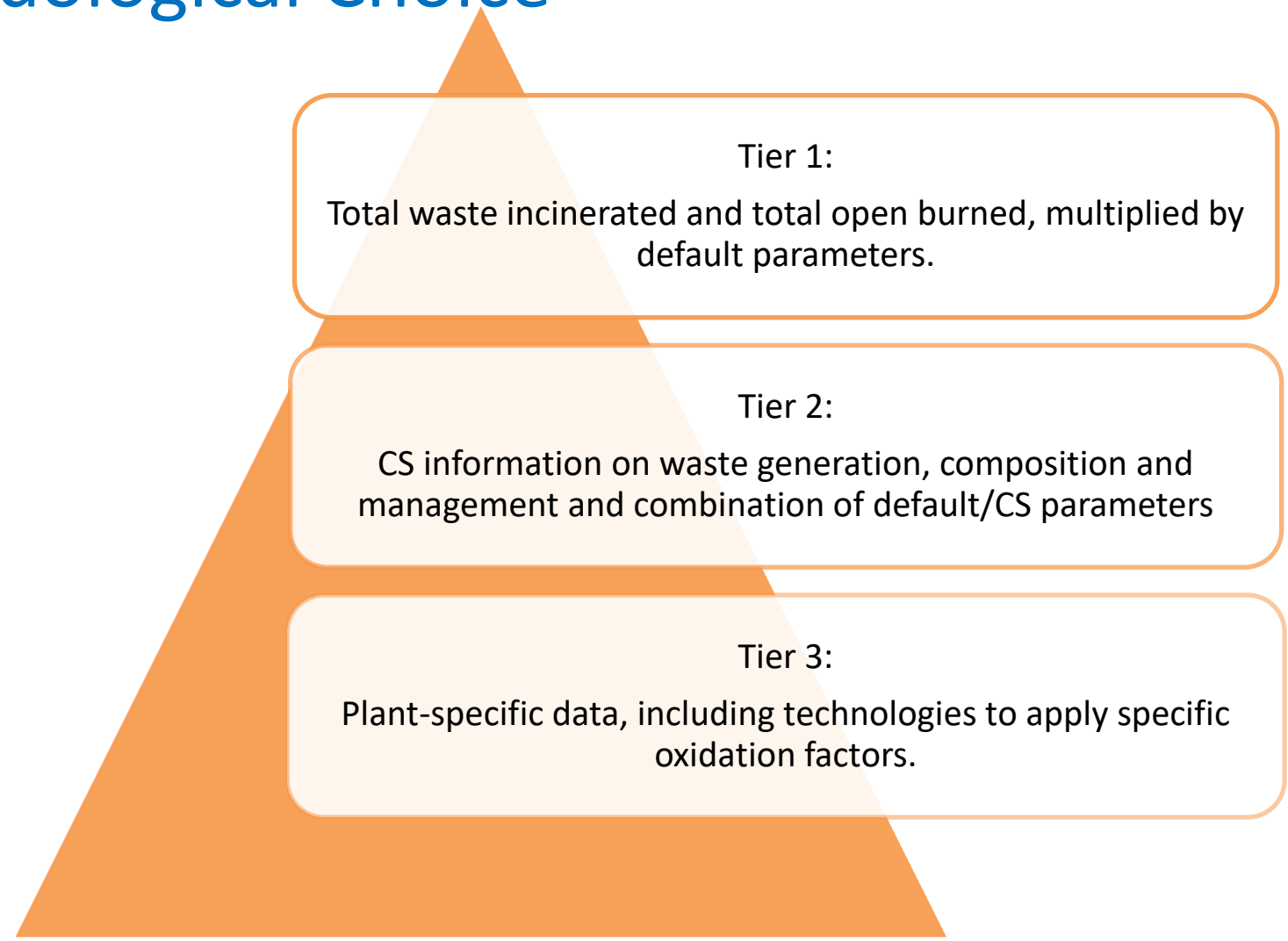
- Waste incineration without energy capture, reported under this category.
- Waste incineration with energy recovery- CO_2, CH_4 and N_2O emissions reported in the energy sector (biogenic CO_2 as a memo item).
- Incineration of sludge from wastewater treatment reported under this category.
- Manure burned without energy recovery reported under this category.
- Field burning of agricultural residues reported under the Agriculture sector

CO_2 Emissions from Waste Incineration and Open Burning- General Approach

General approach applies to all methodological tiers and can be performed at varying levels of detail and complexity



CO_2 from Incineration and Open Burning: Methodological Choice



Collection of AD: Waste Incineration

Waste incinerated

- Amount of waste incinerated can be determined based on IPCC defaults, or national statistics/surveys, companies.
  - Note: There may be a difference between composition of waste generated, and the composition of waste incinerated. The latter is preferred.

- Waste composition relevant for CO_2 emissions from MSW.

- Inventory report should describe methods for collecting AD amount and composition.

- Use the same AD across all gases, CO_2, CH_4 and N_2O.

Question: Do you have any information on waste incineration: e.g. discuss with hospitals the combustion of clinical waste?

Collection of AD: Open Burning

Open burning

- Amount of waste open burned generally not available from statistics (may use a periodic survey/ expert judgement). Defaults also not in the IPCC GL.

EQUATION 5.7
TOTAL AMOUNT OF MUNICIPAL SOLID WASTE OPEN-BURNED

$$MSW_B = P \bullet P_{frac} \bullet MSW_P \bullet B_{frac} \bullet 365 \bullet 10^{-6}$$

Where:

MSW_B	=	Total amount of municipal solid waste open-burned, Gg/yr
P	=	population (capita)
P_{frac}	=	fraction of population burning waste, (fraction)
MSW_P	=	per capita waste generation, kg waste/capita/day
B_{frac}	=	fraction of the waste amount that is burned relative to the total amount of waste treated, (fraction)
365	=	number of days by year
10^{-6}	=	conversion factor from kilogram to gigagram

For developed countries, may be fraction of rural population.
For developing, amount of waste not collected, or collected and put in open dumps

The amount of waste that actually burns (i.e. is not compacted), between 0-1. If no further information, can use 0.6

Question: There are no default values for Pfrac in the IPCC Guidelines? How might you estimate this?

Exercise #1: Estimate the amount of waste open burned

It's your turn. Please work in small groups to estimate the amount of open waste burned in Belize for 2014. Refer to section 5.3.2 of the 2006 IPCC Guidelines, in particular, Equation 5.7 and Box 5.1, and information available in table 2.1 in Volume 5, Chapter 2 of the IPCC Guidelines.

Assumptions

- Population = 358,899 in 2014 (pg. 4 of NC3)
- P_{frac}: For the purposes of this exercise, use Table 2.1 of IPCC GL, suggests 17% (either incinerated or "other"). In reality should be sum of waste "not collected" and waste "collected" and added to dumps.

EQUATION 5.7
TOTAL AMOUNT OF MUNICIPAL SOLID WASTE OPEN-BURNED

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Exercise #1: Estimate the amount of waste open burned in Belize

Question	Answer
1. Total population?	358,899 in 2014 (pg. 4 of NC3)
2. Fraction of population burning waste?	*For exercise, use Table 2.1 of IPCC GL, suggests 17% (either incinerated or “other”)
3. Fraction of waste in these dumps that actually burns?	In the absence of information, assume 0.6
4. Per capita waste generation?	0.49 tonnes/capita/year = 1.34 kg/capita/day (Table 2.1 of 2006 GL)
5. Calculate amount of waste open burned.	$MSW_B = P \bullet P_{frac} \bullet MSW_P \bullet B_{frac} \bullet 365 \bullet 10^{-6}$ = 358,899 *0.17 *1.34 kg/capita/day *0.6 *365 * 10^{-6} =???

Exercise #1: Estimate the amount of waste open burned in Belize

Question	Answer
1. Total population?	358,899 in 2014 (pg. 4 of NC3)
2. Fraction of population burning waste?	*For exercise, use Table 2.1 of IPCC GL, suggests 17% (either incinerated or “other”)
3. Fraction of waste in these dumps that actually burns?	In the absence of information, assume 0.6
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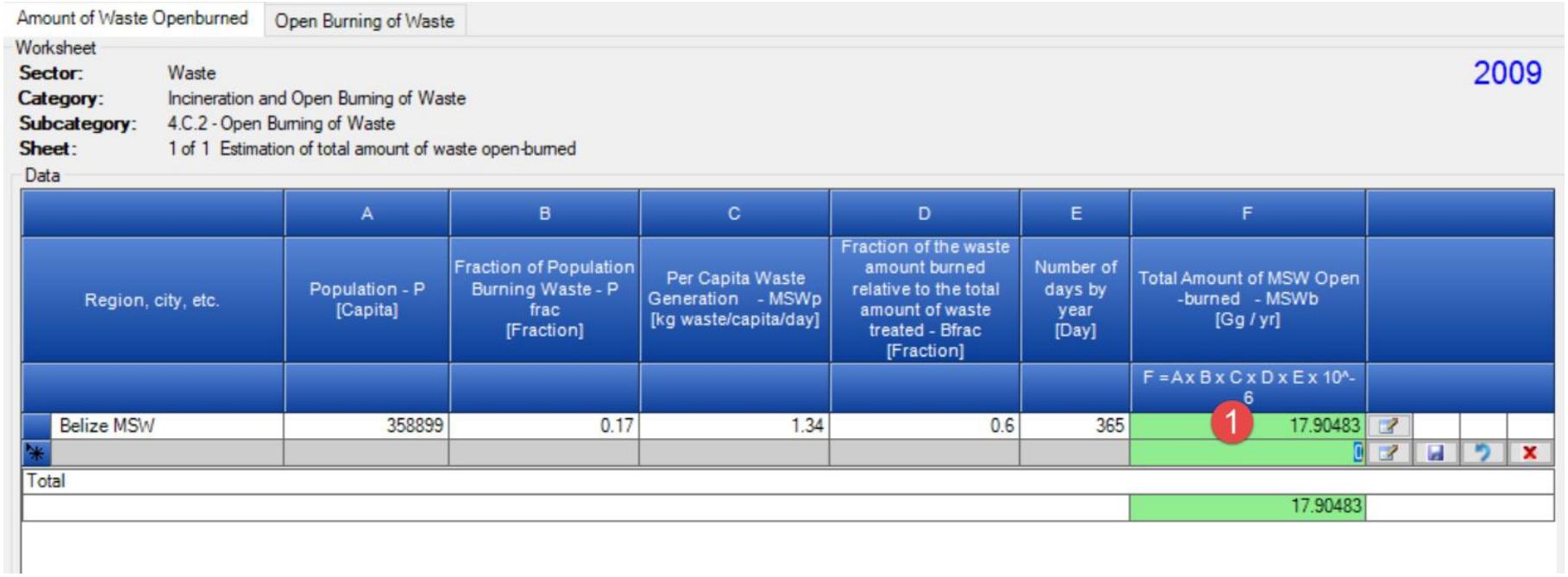
5. Calculate amount of waste open burned.	$MSW_B = P \bullet P_{frac} \bullet MSW_P \bullet B_{frac} \bullet 365 \bullet 10^{-6}$ = 358,899 *0.17 *1.34 kg/capita/day *0.6 *365 * 10^{-6} **= 17.9 Gg /year**

IPCC Software- Calculate Amount of Open Waste Burned



Amount of Waste Openburned | Open Burning of Waste

Worksheet

Sector: Waste
Category: Incineration and Open Burning of Waste
Subcategory: 4.C.2 - Open Burning of Waste
Sheet: 1 of 1 Estimation of total amount of waste open-burned

2009

Data

	A	B	C	D	E	F
Region, city, etc.	Population - P [Capita]	Fraction of Population Burning Waste - P frac [Fraction]	Per Capita Waste Generation - MSWp [kg waste/capita/day]	Fraction of the waste amount burned relative to the total amount of waste treated - Bfrac [Fraction]	Number of days by year [Day]	Total Amount of MSW Open -burned - MSWb [Gg / yr]
						F = A x B x C x D x E x 10^-6
Belize MSW	358899	0.17	1.34	0.6	365	17.90483
Total						17.90483

1

1. This is the same answer that you calculated earlier…..