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Emission inventory (EI): Air pollutions and greenhouse gases

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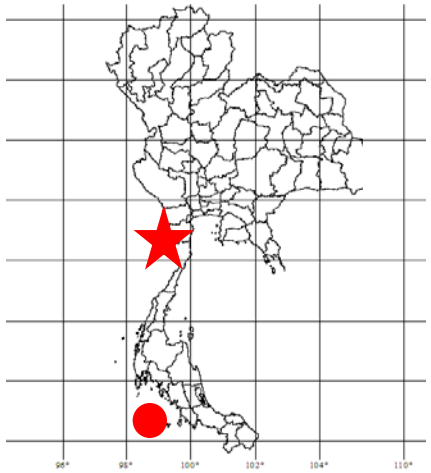
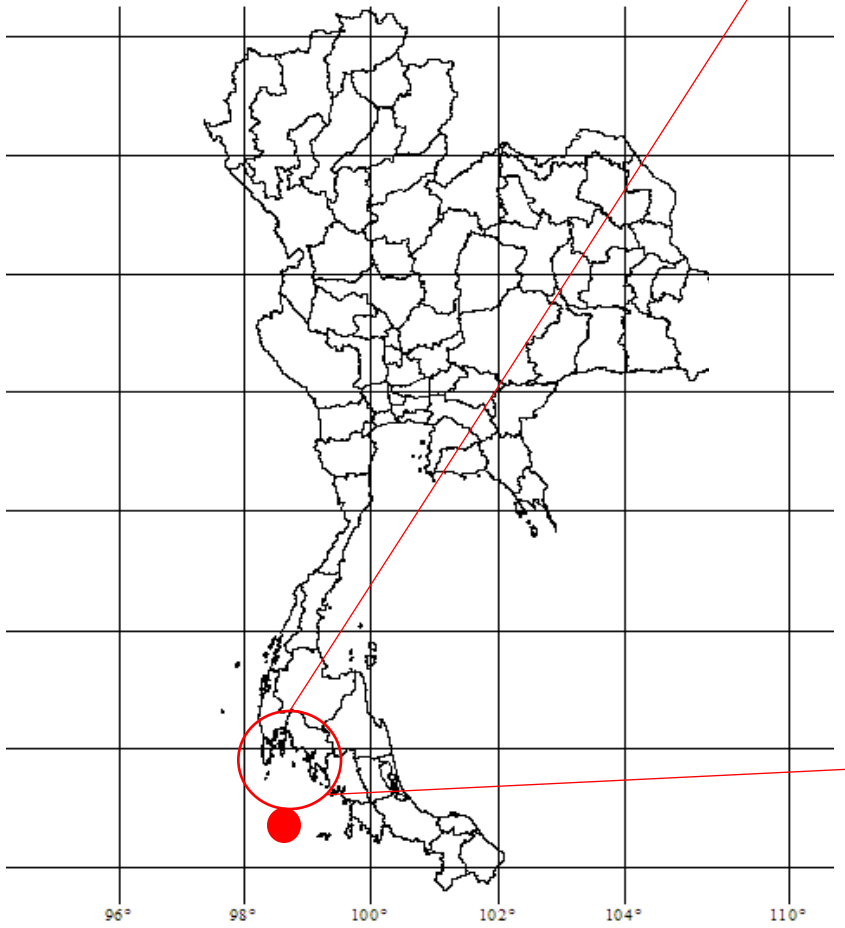
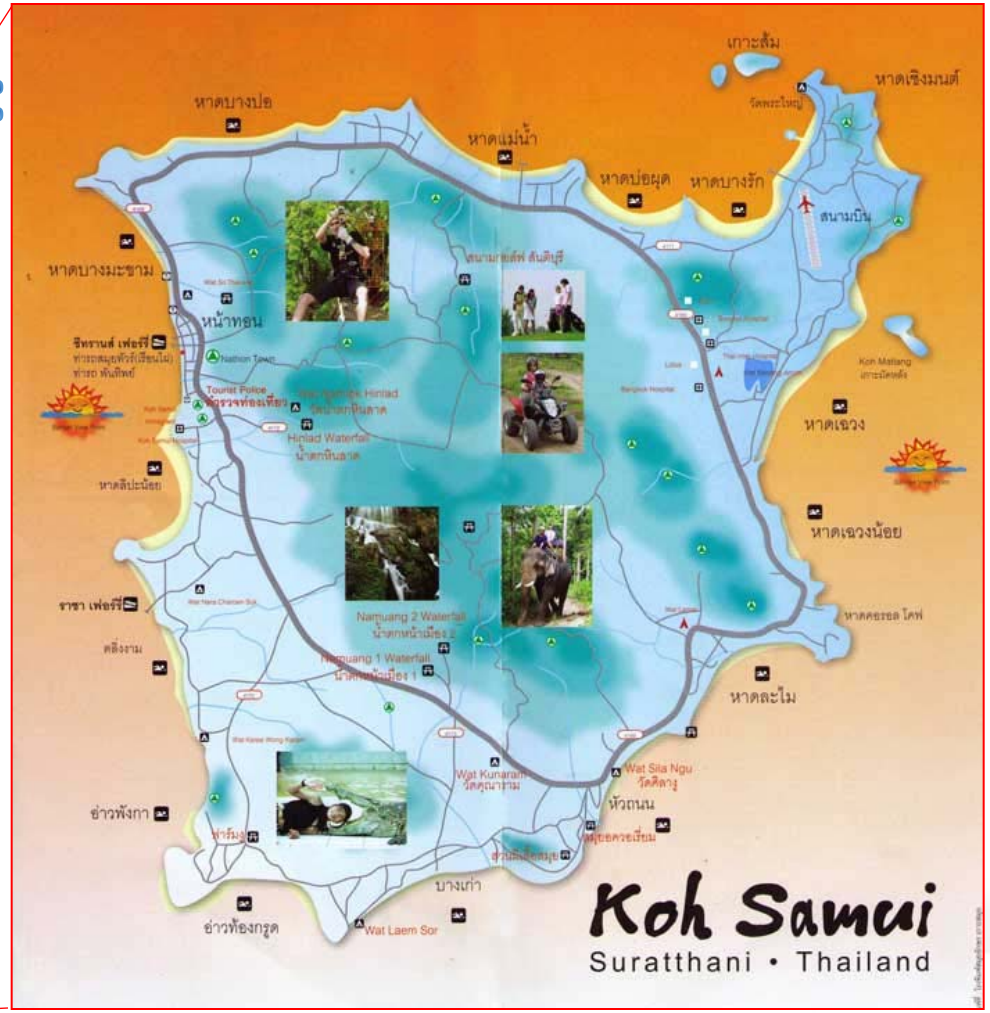
Walailak University



- Walailak University is designed as a comprehensive university with a variety of fields of study (11 schools).
- The campus is 780 kilometers south of Bangkok.
- The University has a total area of 3,600 acres, making it the largest campus of any university in Thailand.

TENTATATIVE EXCURSION: SAMUI ISLAND





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WHAT IS "EMISSION INVENTORY"?

"an estimation of the amount of pollutants discharged into the atmosphere that can be broken down by specified source categories in a certain geographical area and within a specified time span (e.g., in a calendar year)." (EPA)

"an accounting of the amount of pollutants discharged into the atmosphere and usually contains the total emissions for one or more specific greenhouse gases or air pollutants, originating from all source categories in a certain geographical area and within a specified time span, usually a specific year." (Wikipedia)

What is “Air pollutions”?

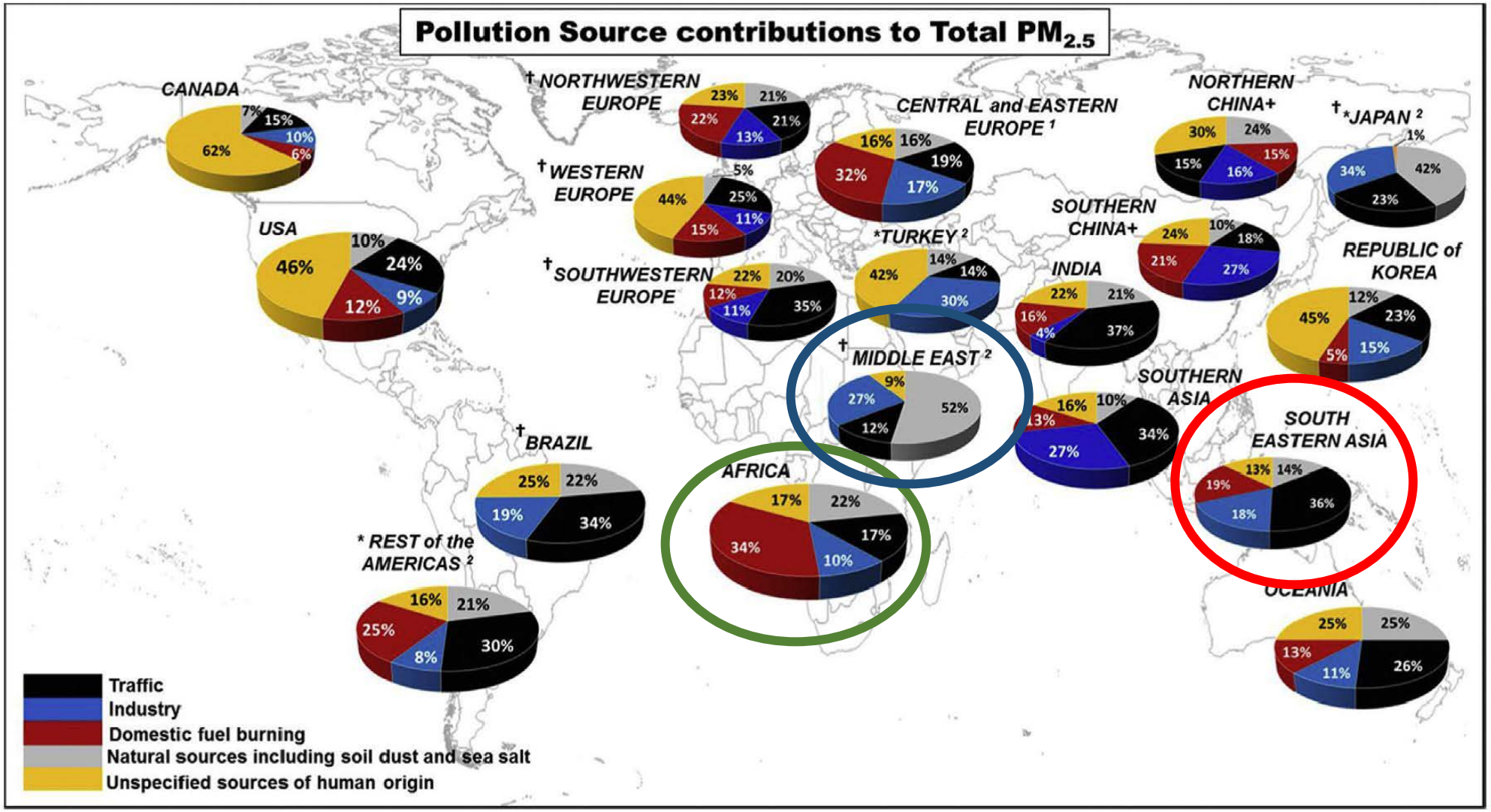
- Normally, air pollutions referred to the contaminants in the ambient atmosphere that are harmful to human health and environment.
  - Particulate matter (PM): TSP, PM_{10}, $PM_{2.5}$
  - Nitrogen dioxide (NO_2)
  - Sulfur dioxide (SO_2)
  - Carbon monoxide (CO)
  - Lead (Pb)
  - Ozone (O_3)
  - Volatile organic compounds (VOCs)

“Criteria pollutants”

WHAT IS "GREENHOUSE GASES (GHGS) :

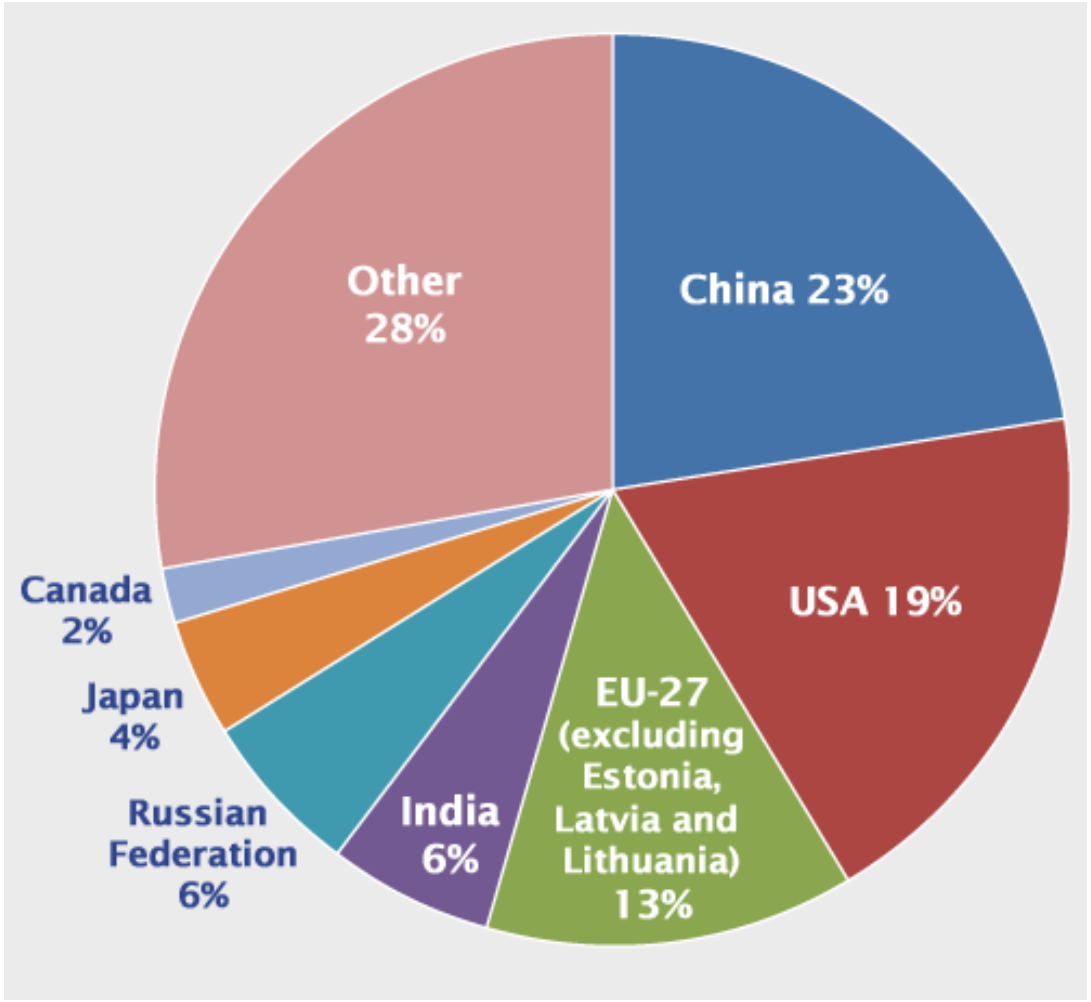
- Following the **Kyoto Protocol and IPCC guidelines**, GHGs includes:
  - Carbon dioxide (CO_2)
  - Methane (CH_4)
  - Nitrous oxide (N_2O)
  - Perfluorocarbons (PFCs)
  - Hydrofluorocarbons (HFCs)
  - Sulfur hexafluoride (SF_6)
  - Nitrogen trifluoride (NF_3)

How can we use Emission inventory?



Source: https://ec.europa.eu/jrc/en/news/what-are-main-sources-urban-air-pollution

2008 Global CO_2 emissions from fossil fuel combustion and some industrial processes



Source: http://www.epa.gov/climatechange/ghgemissions/global.html

How to conduct EI?

Comprehensive listing by sources of air pollutant emissions :

a geographic area (spatial)

a specific time period (temporal)

Top down approach; minimum resources, **high uncertainty**

Several estimation methods:

- ❖ CEM (Continuous Emission Monitoring)
- ❖ Fuel analysis
- ❖ **Emission estimate : E = EF x Activity data**
- ❖ Emission models
- ❖ Surveying etc.

Bottom up approach; **more accurate**, more resources

Semi-approach

Example of emission estimate:

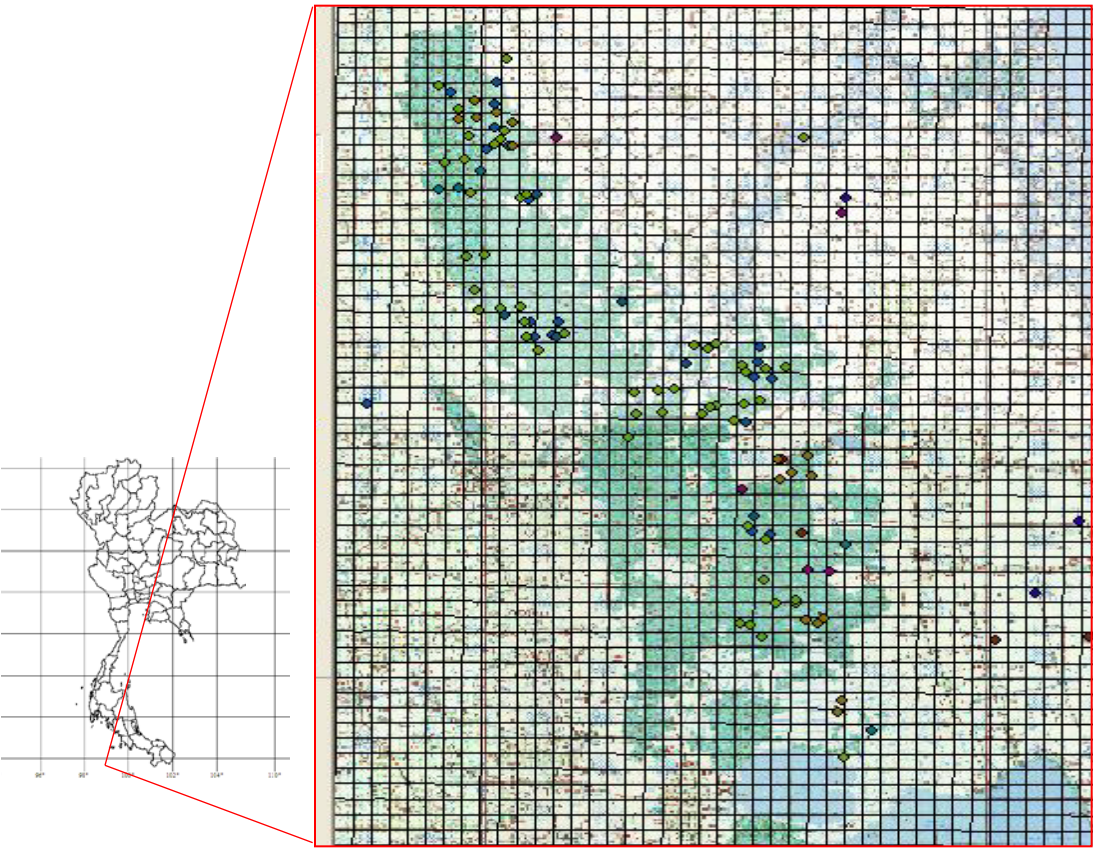
E = Emission factor (EF) x Activity data (AD)

EF_{CO} = 82-200 mg/g-smoked tobacco

(Klepeis et al., 2003)

Gram (g) of smoked tobacco

Examples of EI for air quality management in Thailand



Hotspot data from MODIS satellite in 2012

$$Em_{i,j} = \sum_{j} M_j \times EF_{i,j} \times 10^{-3}$$

where,

$Em_{i,j}$ = Emission of pollutant i from land cover type j (tonne/yr)

M_j = Amount of burned biomass on land cover type j (tonne/yr)

$EF_{i,j}$ = Emission factor of pollutant i from land cover type j (g/kg of dry matter).

$$M_j = A_{ba} \times \rho_j \times \eta_j$$

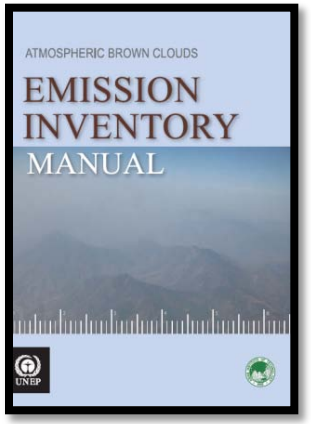
where,

A_{ba} = Actual burned area (ha/yr)

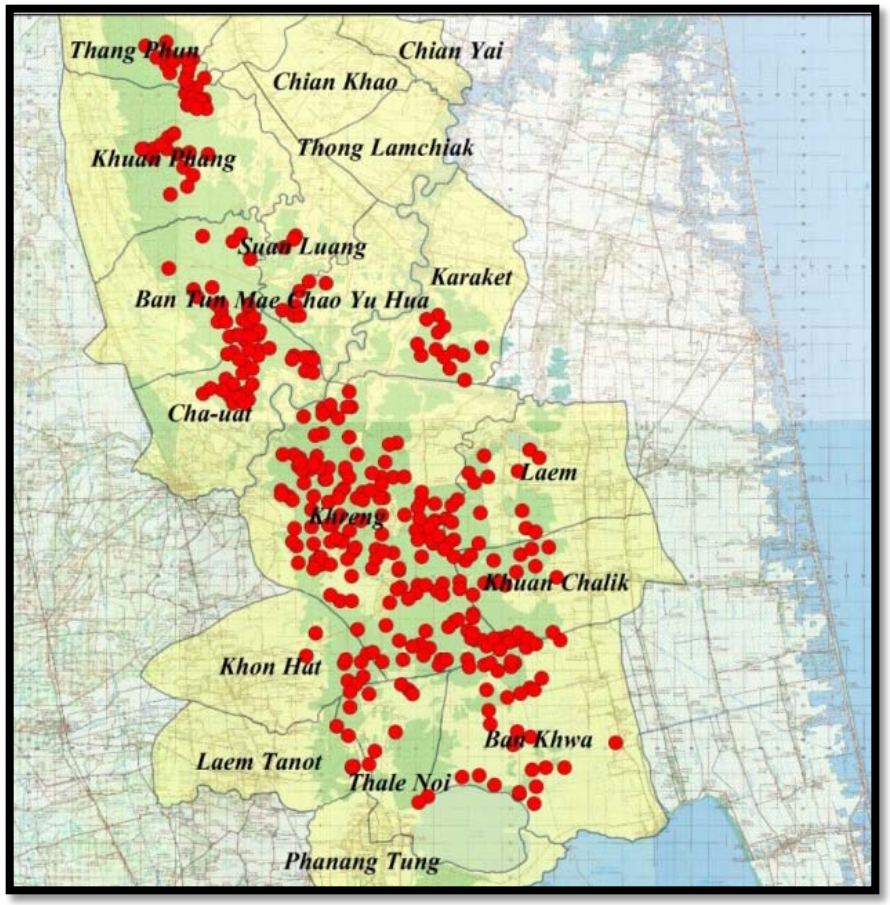
ρ_j = Dry matter density (tonne/ha)

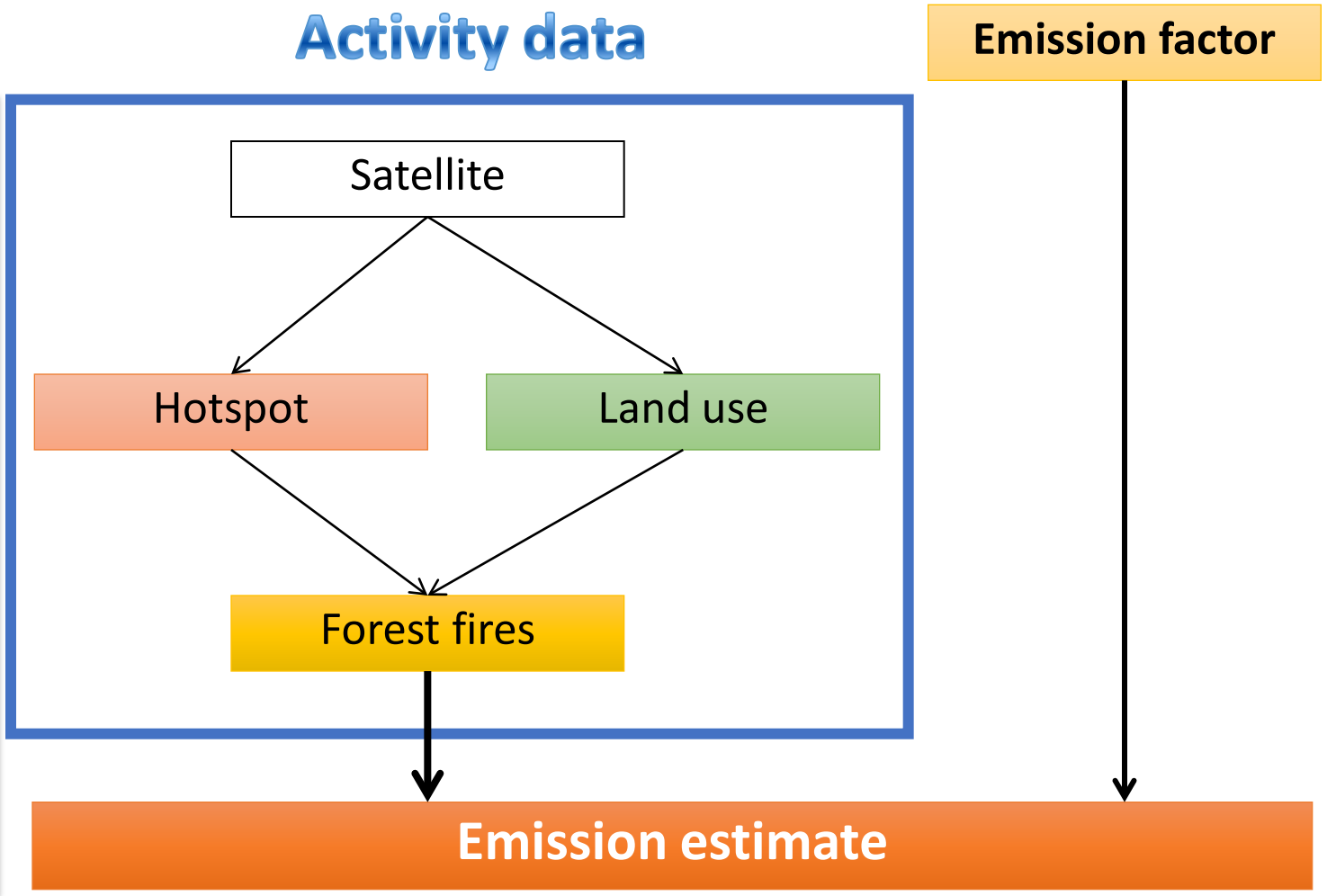
η_j = Burning efficiency (oxidized in the combustion)

Note: Emission methods and values taken mainly from ABC EIM (2013) and Andreae and Merlet (2001)



(FOREST FIRES)





Hotspot data from MODIS satellite in 2004 - 2014

Examples of EI for Greenhouse gas management in Thailand

Revised 1996 IPCC and GPG 2000 IPCC Guidelines	
6A. Solid waste disposal on land	
6A1 CH_4 emission from solid waste disposal on land (CH_4 Emission, Gg CH_4 /yr)	**Tier 1**: Mass Balance CH_4 Emission = $[(MSW_T * MSW_F * L_o) - R] * (1-OX)$
	Tier 2: First Order Decay CH_4 Emission $Q_{T,x} = k * R_x * L_O \, e^{-k(T-x)}$ $Q_T = \sum Q_{T,x}$ (for x = initial year to T)

Activity data required

TIER 1;
- MSW_T = Total MSW Generated
- MSW_F = Fraction of MSW disposed at SWDS
- Lo = Methane Generation Potential, depending on waste composition
  - = [MCF*DOC*DOCF*F*16/12]
- DOC = fraction of degradable organic carbon, Gg C/Gg waste
  - = $[\sum (DOC_i * W_i)]$
- DOCF = Fraction of degradable organic carbon which decomposes
- MCF = Methane Correction Factor, depending on disposal method

TIER2;
- R_x = The amount of waste disposed in year x
- x = The year of waste input
- Lo = Methane generation potential
- k = First order decay rate constant, depending on waste composition
- T = Current (estimation) year

(SOLID WASTE)

Activity data required for estimating GHG emission

	Tier 1	Tier 2
MSW Quantity and characteristics:	• Amount of MSW generation/ recycled/ sent for disposal • MSW components (food, paper, wood, plastics, etc.) for estimation of Lo • carbon contents in the different waste types (degradable organic carbon)	• Amount of MSW generation/ recycled/ sent for disposal • MSW components (food, paper, wood, plastics, etc.) for estimation of Lo/ k • carbon contents in the different waste types (degradable organic carbon)
Disposal Management:	• Fraction of MSW disposed by each method (OD, Sanitary LF, semi-aerobic LF) • Basic information of disposal condition e.g. depth of wastes	• information of disposal site necessary • Disposal method (OD, Sanitary LF, semi-aerobic LF) • Depth of buried wastes • Pending /closing year of SWDS
	Top down approach	Bottom up approach

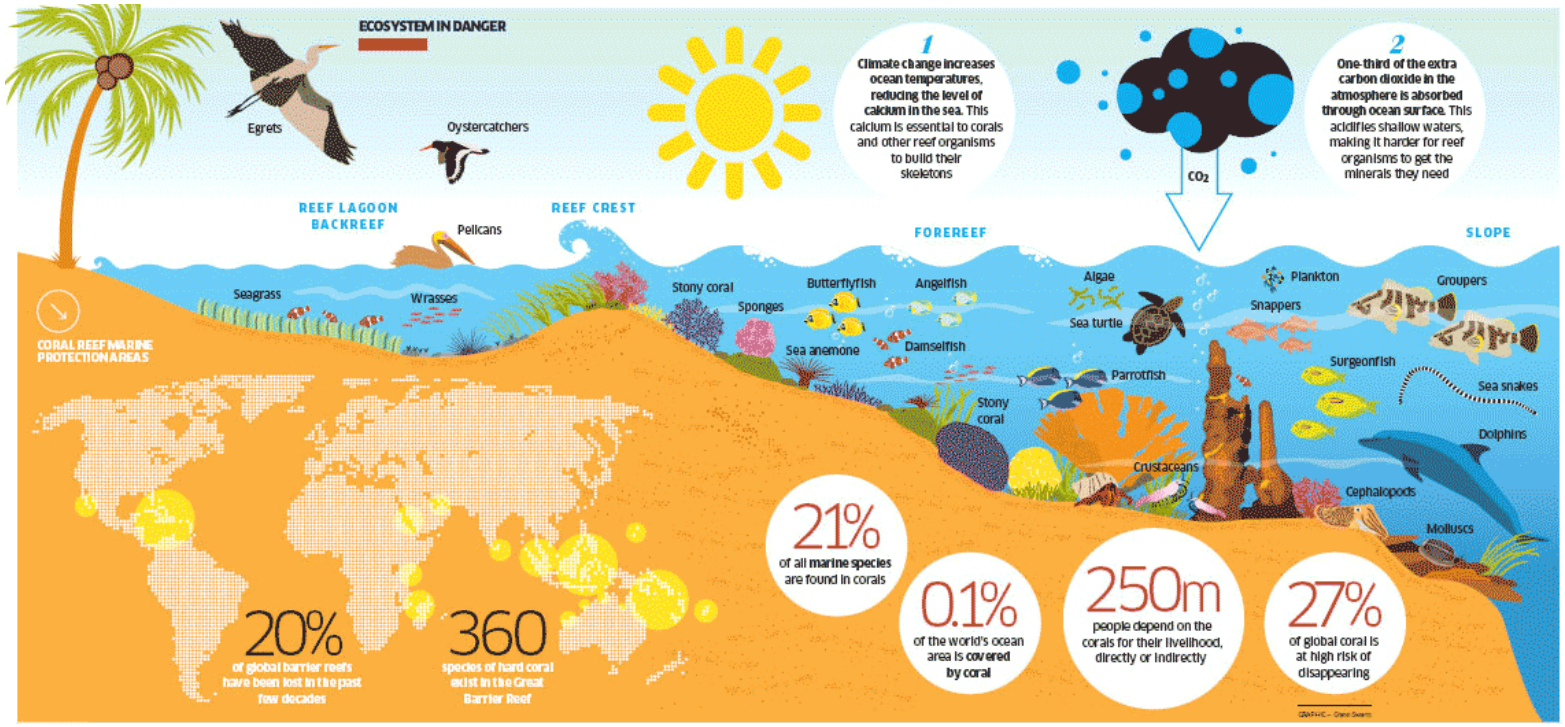
CO_2 / CH_4 /N_2O

EF for estimation of GHG emission from solid waste disposal (6A)

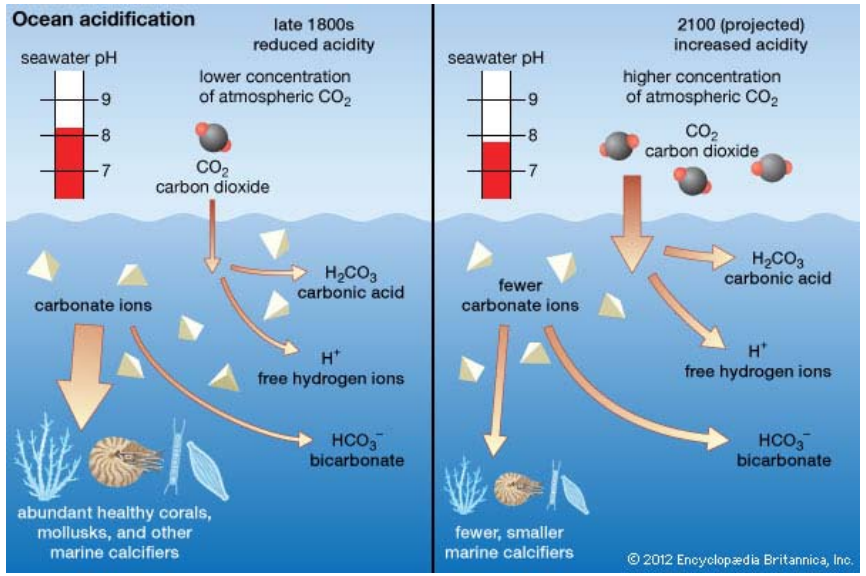
TIER 1	Emission Factors	Default value (IPCC 1996 GL)	EF value – Tier 1
Degradable Organic Carbon (DOC)	Paper and textiles	40	0.14
	Other (nonfood) organics	17	
	Food waste	15	
	Wood and straw waste	30	
Fraction of Degradable Organic Carbon Dissimilated (DOC_F)			0.77
Methane Correction Factor (MCF)	LF	1.0	1.0
	OD>5m	0.8	-
	OD-<5m	0.4	0.4
Fraction of Methane in Landfill Gas (F)		0.5	0.53
Methane Recovery (R)		0	0
Oxidation Factor (OX)	LF	0	0.017
	OD	0	0

TIER 2	Emission Factors	Default value (IPCC 1996GL)	Type	EF value – Tier 2
Methane generation potential (L_0), m^3/Mg of refuse	Wet climate area	180-200	Metropolitan	121.40
	Medium moisture climate	160-189	LF	130.22
	Dry climate	140-160	OD	70.42
Methane generation rate constant (k), 1/yr	LF	0.003-0.4	LF	0.07
	OD		OD	0.03
Fraction by Volume of methane in landfill gas ($F_)$				-
Density of methane at STP Condition				0.714 kg/m^3

Example of EI of GHG Effects on the Ocean Acidification



Source: http://scienceprogress.org/2011/09/ocean-acidification-beyond-the-carbon-debate/



Source: http://www.britannica.com/science/ocean-acidification

Activity data:

-CO_2 level in the atmosphere and ocean solubility

- Aquatic ecosystem, GHG emission sources and sinks, etc.

Summary

- Emission inventory (EI) is an estimation of the amount of pollutants/gases discharged into the atmosphere and its effect to the environmental situations.
- EI can be used for air quality and greenhouse gases management, as well as used for input data for modeling study.
- Accuracy of EI data depends on the selected approach which is depended mainly on the available data.

Thank you!!