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Recent Progress of Air Pollution Modelling for co-benefit estimation

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Contents

Indonesia’s Biomass Burning model

Quantification of co-benefit of LCS policies in Iskandar Malaysia’s LCS study.

Update of the study in the effectiveness of Air pollution prevention plan of Chinese provinces

Introduction

Backgrounds

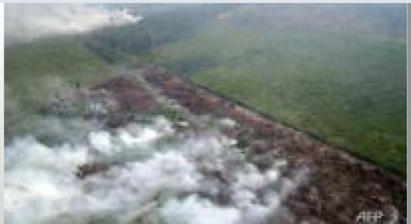
Biomass burning is now widely recognized as one of the most important emission sources

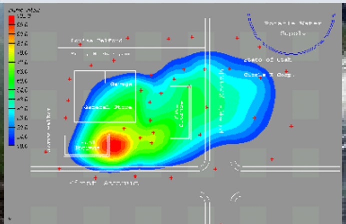
Indonesia is one of the major area of biomass burning in the world

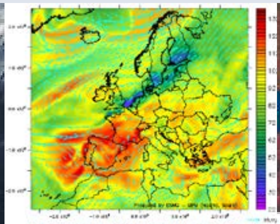
Biomass burning emissions inventory is important to evaluate the impacts

Objectives

quantify the emissions (greenhouse gases and air pollutants) of biomass burning in Indonesia during the recently year, 2013







Outline of Study

Estimation of the emission of air pollutants → Regional Air Quality model (CMAQ) → Acute and Chronic impact of Haze

Control policies on AFOLU

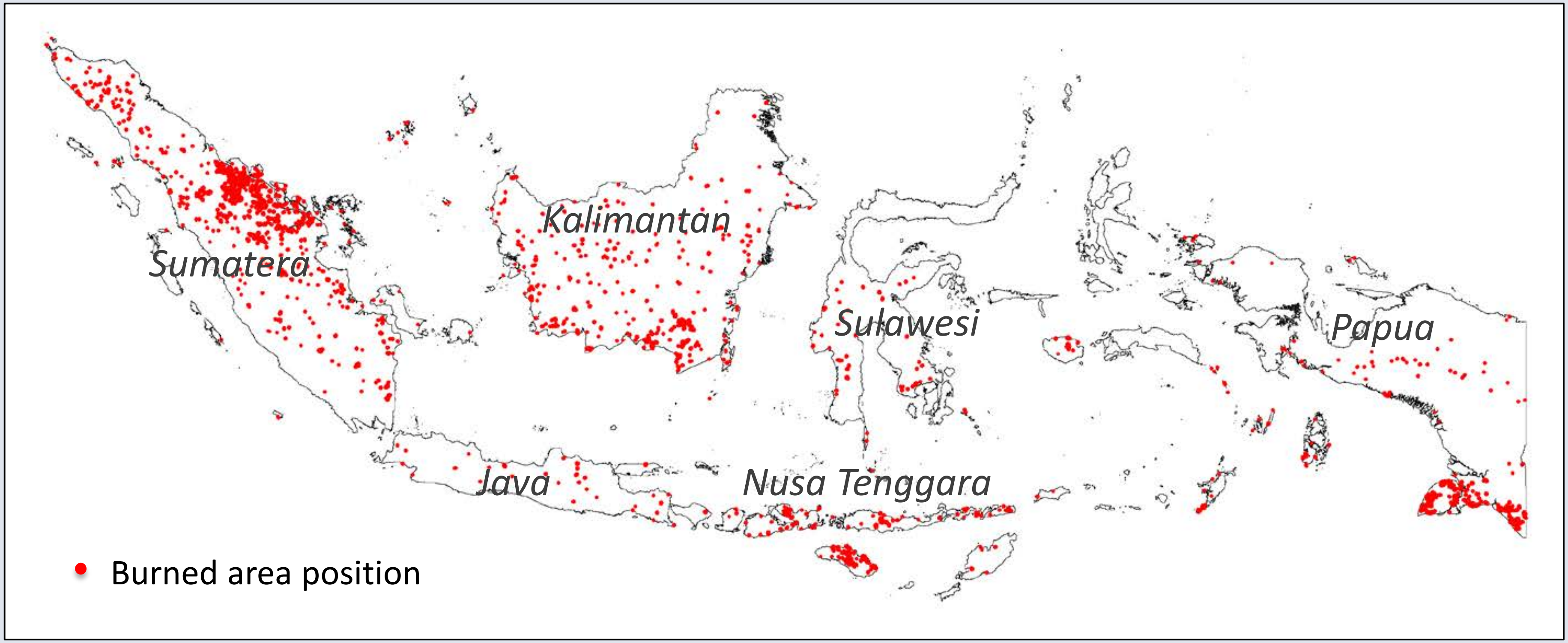
Methodology

$$Emissions = \sum_{i=1}^{n} (B \times F \times CE \times EF)$$

(Seiler & Crutzen, 1980)

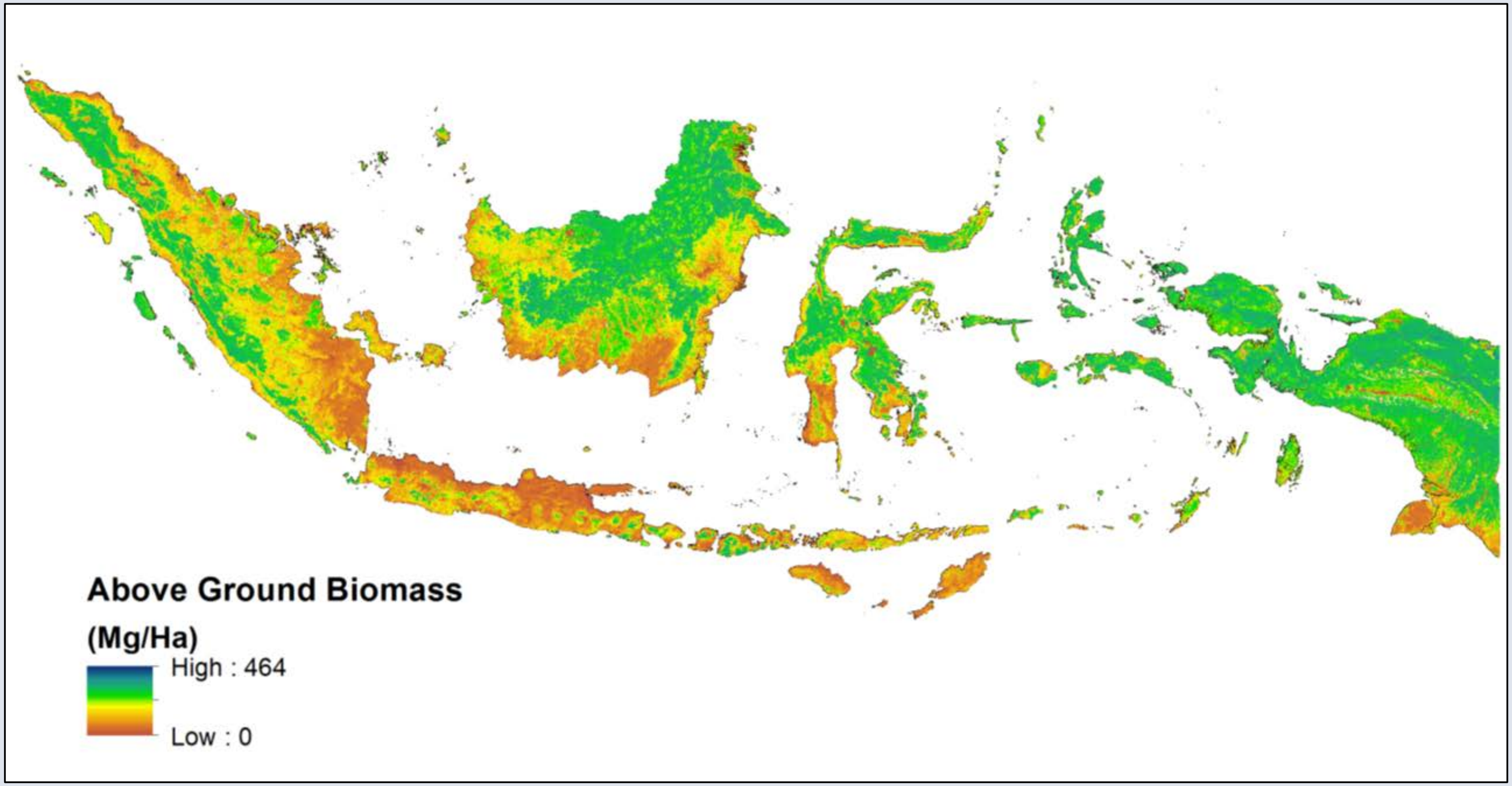
Notation	Definition	Data used
B	burned area (m^2)	MODIS product (MCD64A1)
F	available fuels for combustion (kg/m^2)	Above ground: Pantropical National Carbon Dataset 2010 Below ground: Indonesia peat distribution 2002
CE	combustion efficiency; the fraction of combusted fuel to the total amount (unitless)	derived from Vegetation Condition Index (VCI)
EF	emissions factors; the mass of species per mass of dry matter burned (g/kg)	collected from available publications
i	land cover types	Indonesia Land Cover 2011

Burned Area



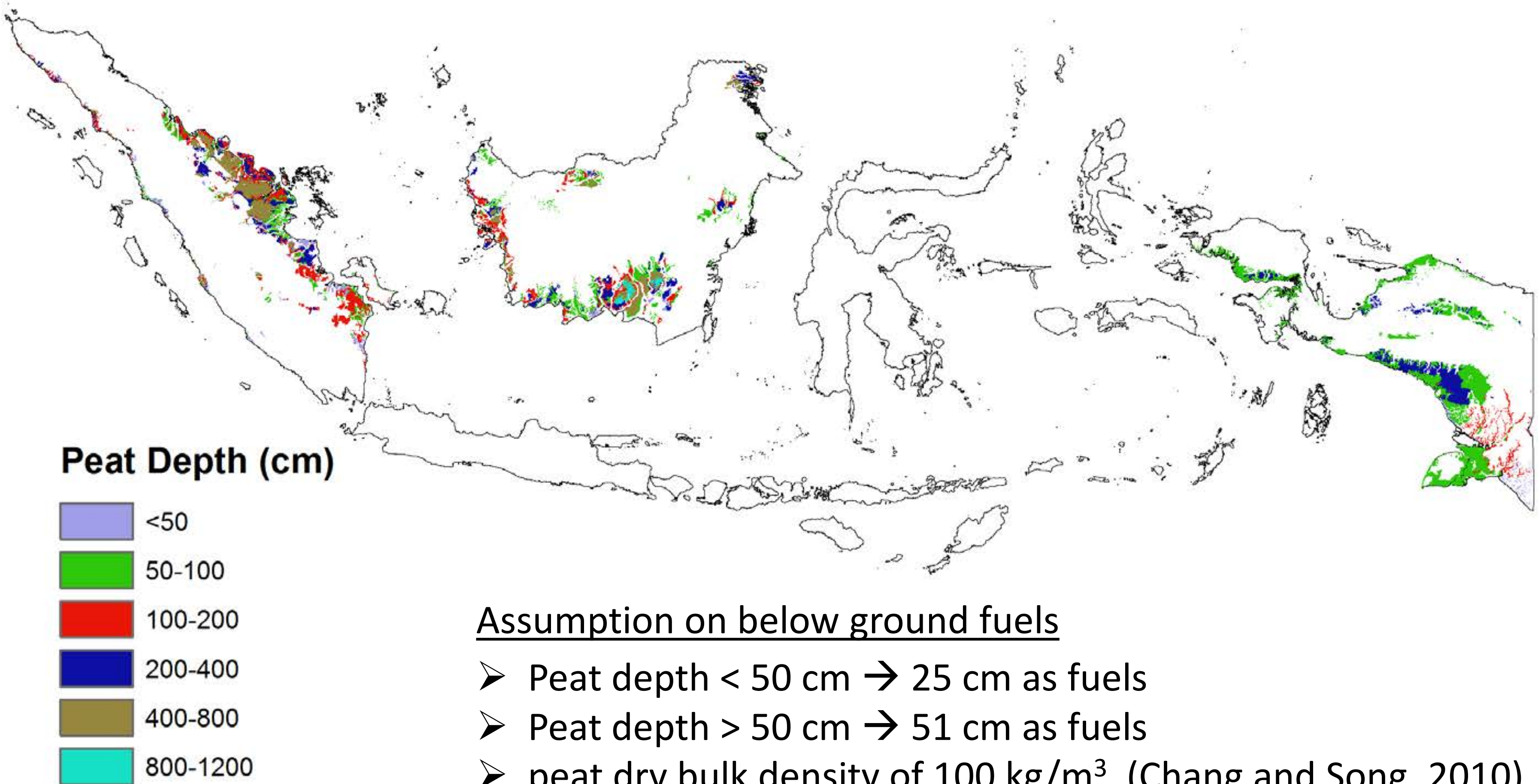
- Data: MODIS MCD64A1 (monthly, 500 m resolution)
- Most of open fire biomass burning during 2013 located at the Eastern part of Sumatera island (Riau Province)
- Kalimantan also suffered from biomass burning

Above Ground Biomass Density



- Data: Pantropical Carbon Dataset 2010 (GeoTiff format, 500m resolution)
- Above Ground Biomass (AGB) → trees, grass, shrub, etc.
- Papua and middle part of Kalimantan have high AGB density

Below Ground Biomass Density

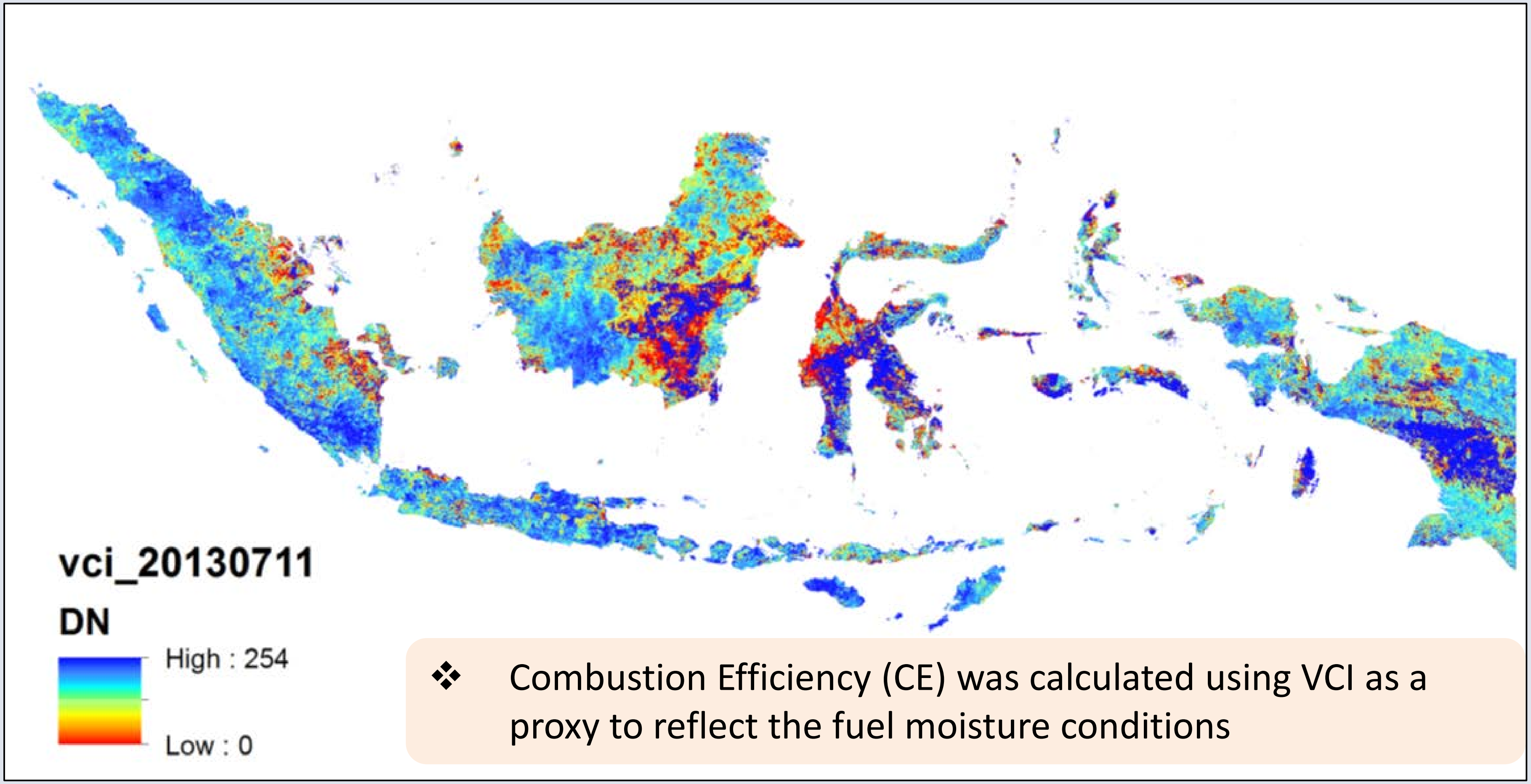


<u>Assumption on below ground fuels</u>

- Peat depth < 50 cm → 25 cm as fuels
- Peat depth > 50 cm → 51 cm as fuels
- peat dry bulk density of 100 kg/m^3 (Chang and Song, 2010)

- Data: Indonesia peat distribution 2002 (ArcGIS layer format; 1:250,000 scale)
- High BGB density: Eastern part of Sumatera, Southern part of Kalimantan and Papua

Vegetation Condition Index (VCI)

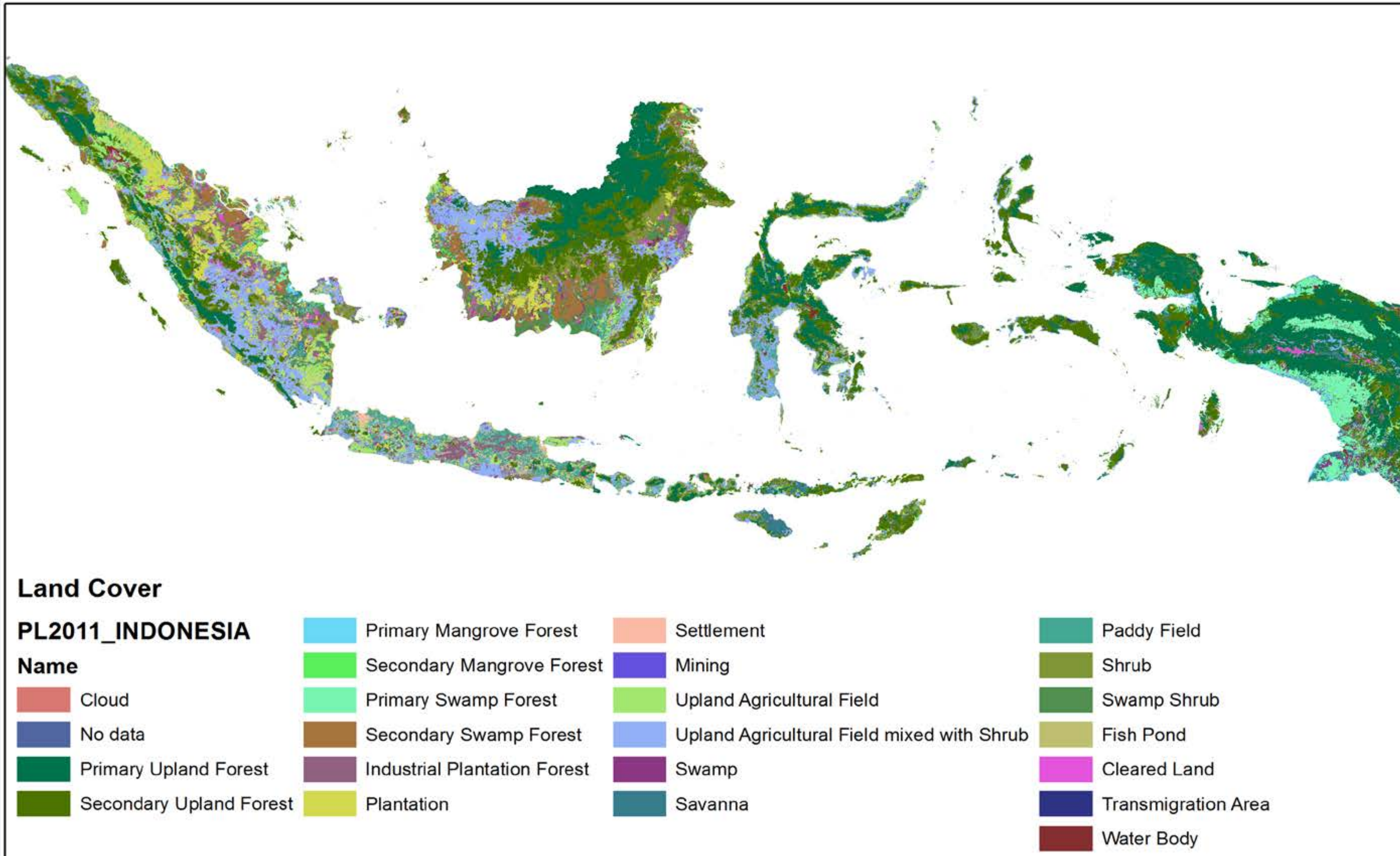


❖ Combustion Efficiency (CE) was calculated using VCI as a proxy to reflect the fuel moisture conditions

❖ VCI derived from SPOT-VGT NDVI data → 10 daily, 1/112°, unitless

❖ VCI values divided into six different categories, representing fuel moisture conditions from very dry to very wet → very high CE to very low CE

Land Cover



- ❖ Data source: Indonesia Land Cover 2011 (Ministry of Forestry, Indonesia)

Emission Factors

No	MOF Classification	Re-Classification	Emission Factors (g/kg)											
			CO2	CH4	N2O	SO2	NOx	CO	NMVOC	NH3	BC	OC	PM2.5	PM10
1	Primary Upland Forest	Tropical Evergreen Forest	1601	6.44	0.2	0.43	1.44	106	8.1	1.1	0.64	6.79	14.8	18.5
2	Secondary Upland Forest													
3	Primary Swamp Forest	Woodlands	1636	4.4	0.21	0.54	2.19	81	5.21	1.44	0.52	3.76	7	10.2
4	Secondary Swamp Forest													
5	Primary Mangrove Forest													
6	Secondary Mangrove Forest													
7	Industrial Plantation Forest													
8	Plantation													
9	Shrub	Shrubland/Savanna	1685.8	2	0.21	0.9	3.9	63	3.4	0.56	0.37	2.62	5.4	8.3
10	Swamp Shrub													
11	Swamp													
12	Upland Agricultural Field mixed with Shrub													
13	Savana													
14	Cleared Land													
15	Settlement													
16	Transmigration Area													
17	Mining													
18	Upland Agricultural Field	Farmland (Combined Crops)	1130	4.56	0.1	0.216	0.7	86.3	7	1.3	0.48	0.7	3.9	8.05
19	Paddy field	Paddy field	1177	9.59	0.07	0.18	2.28	93	7	4.1	0.52	2.99	8.3	9.1
20	Water Body	---	0	0	0	0	0	0	0	0	0	0	0	0
21	Fishpond	---	0	0	0	0	0	0	0	0	0	0	0	0
22	Cloud	---	0	0	0	0	0	0	0	0	0	0	0	0
23	No data	---	0	0	0	0	0	0	0	0	0	0	0	0
	Peatlands		1703	20.8	0.2	0.71	2.26	210	7	2.55	0.57	4.3	9.05	11.8

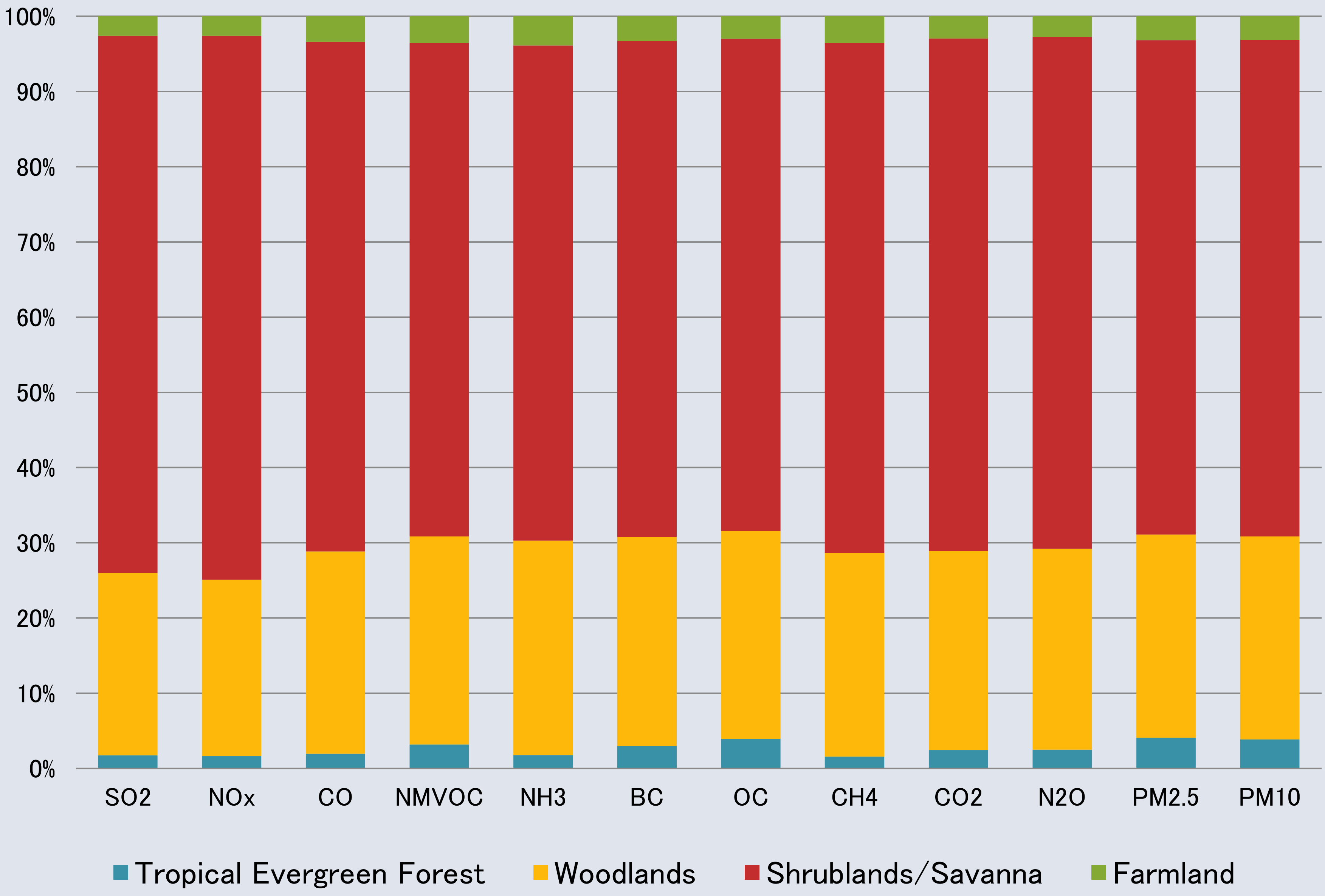
Emissions of each chemical species

2013

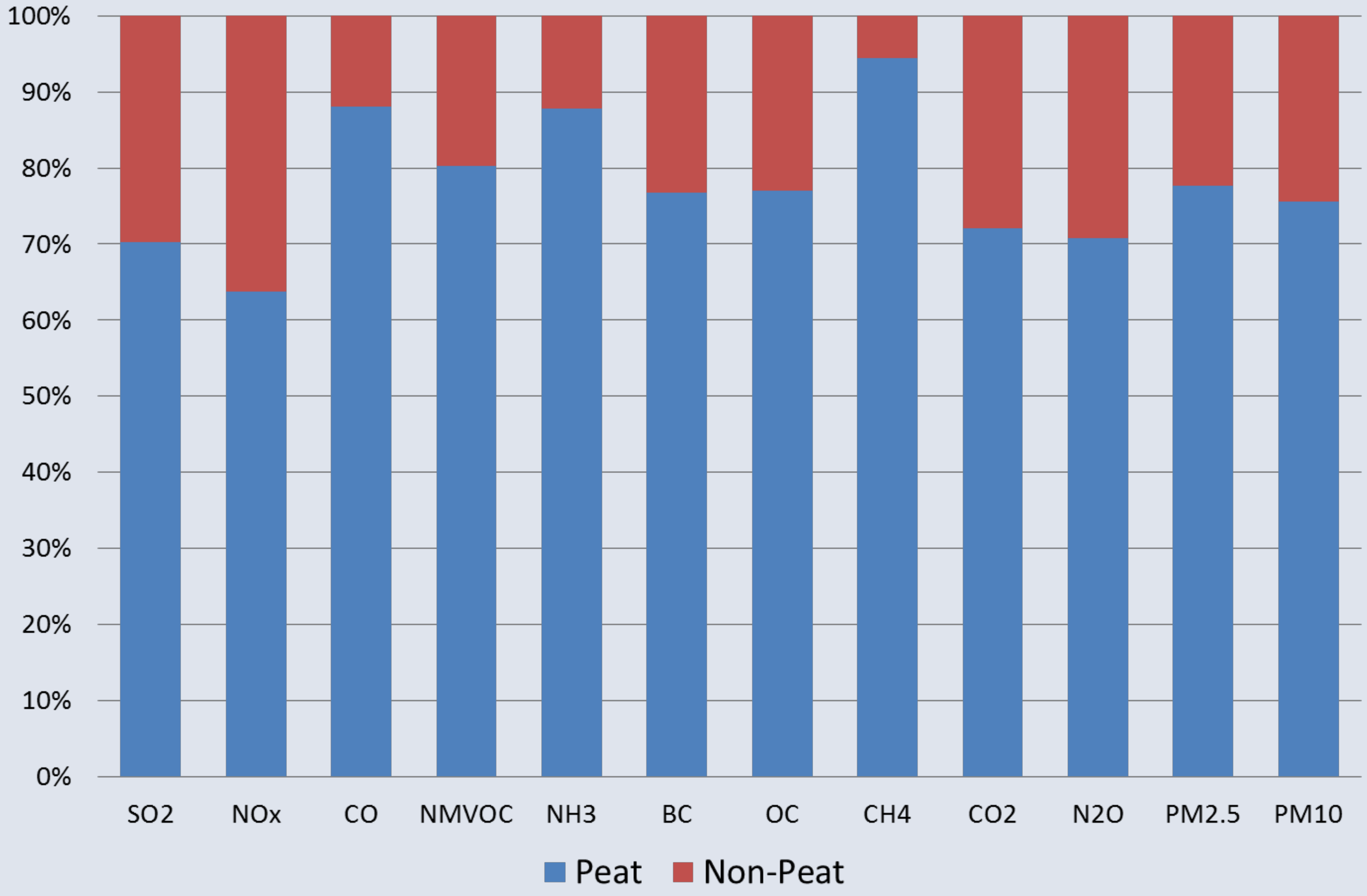
	Emissions (Gg)											
	CO2	CH4	N2O	SO2	NOx	CO	NMVOC	NH3	BC	OC	PM2.5	PM10
Jan	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Feb	130.08	1.03	0.02	0.05	0.19	11.77	0.48	0.14	0.04	0.32	0.68	0.90
Mar	2573.96	22.57	0.31	1.10	3.91	248.82	9.27	3.05	0.80	5.94	12.33	16.69
Apr	624.43	4.44	0.08	0.27	1.02	52.41	2.10	0.63	0.19	1.41	2.93	4.00
May	4227.26	38.25	0.51	1.79	6.28	417.34	15.41	5.15	1.33	9.90	20.46	27.58
Jun	81206.23	736.91	9.74	34.85	122.81	8039.17	295.19	97.69	25.32	189.93	395.00	531.31
Jul	22478.34	199.51	2.70	9.55	33.71	2193.44	82.13	26.72	7.05	53.19	110.69	148.81
Aug	5901.09	54.53	0.70	2.49	8.79	592.52	22.29	7.31	1.88	14.39	30.36	40.27
Sep	33018.88	331.58	3.91	14.09	48.59	3516.62	125.58	42.93	10.53	78.98	166.24	220.91
Oct	13998.18	141.49	1.66	5.99	20.56	1498.54	53.12	18.14	4.46	33.39	70.16	93.37
Nov	77.91	0.16	0.01	0.04	0.16	3.51	0.22	0.04	0.02	0.17	0.36	0.50
Dec	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Total	**164236.35**	**1530.47**	**19.63**	**70.22**	**246.01**	**16574.14**	**605.79**	**201.81**	**51.62**	**387.61**	**809.21**	**1084.34**

- The largest emitted GHG and pollutant are CO_2 (164 Tg) and CO (16 Tg) respectively
- The peak of the emissions was generated on June (49%), which is not the peak of dry season in this area

Contributions of Each Land Cover Type

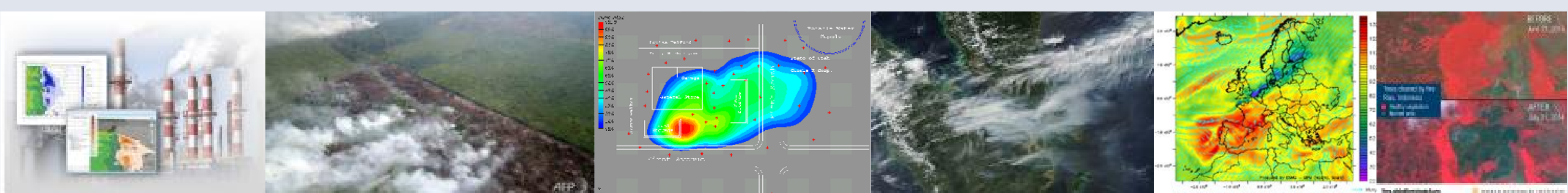


Contributions from Peatlands Fire



Summary

- ✓ The GHGs and air pollutants emissions from biomass burning in Indonesia during 2013 have been assessed.
- ✓ The largest contribution was from shrubland/savanna burning (65%-72%).
- ✓ About 70%-94% of the emissions were generated from peatland fire.



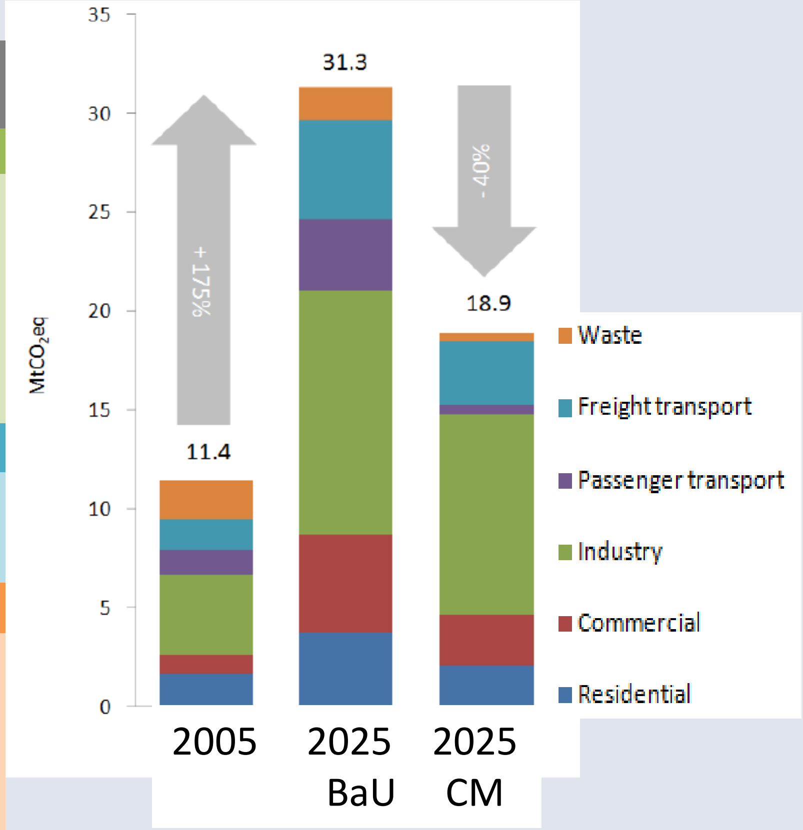
Quantification of Co-benefit of LCS policies on Air Quality

LCS scenarios for policy development in IM

GHG reductions by Actions

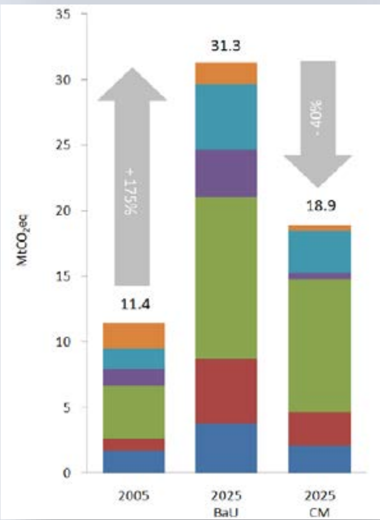
Mitigation Options	ktCO2 Reduction	%
Green Economy	6,937	54%
Action 1 Integrated Green Transportation	1,916	15%
Action 2 Green Industry	1,094	9%
Action 3 Low Carbon Urban Governance**	-	-
Action 4 Green Building and Construction	1,203	9%
Action 5 Green Energy System and Renewable Energy	2,725	21%
Green Community	2,727	21%
Action 6 Low Carbon Lifestyle	2,727	21%
Action 7 Community Engagement and Consensus Building**	-	-
Green Environment	3,094	25%
Action 8 Walkable, Safe and Livable City Design	263	2%
Action 9 Smart Urban Growth	1,214	10%
Action 10 Green and Blue Infrastructure and Rural Resources	392	3%
Action 11 Sustainable Waste Management	1,224	10%
Action 12 Clean Air Environment**	-	-
Total	12,467**	100%

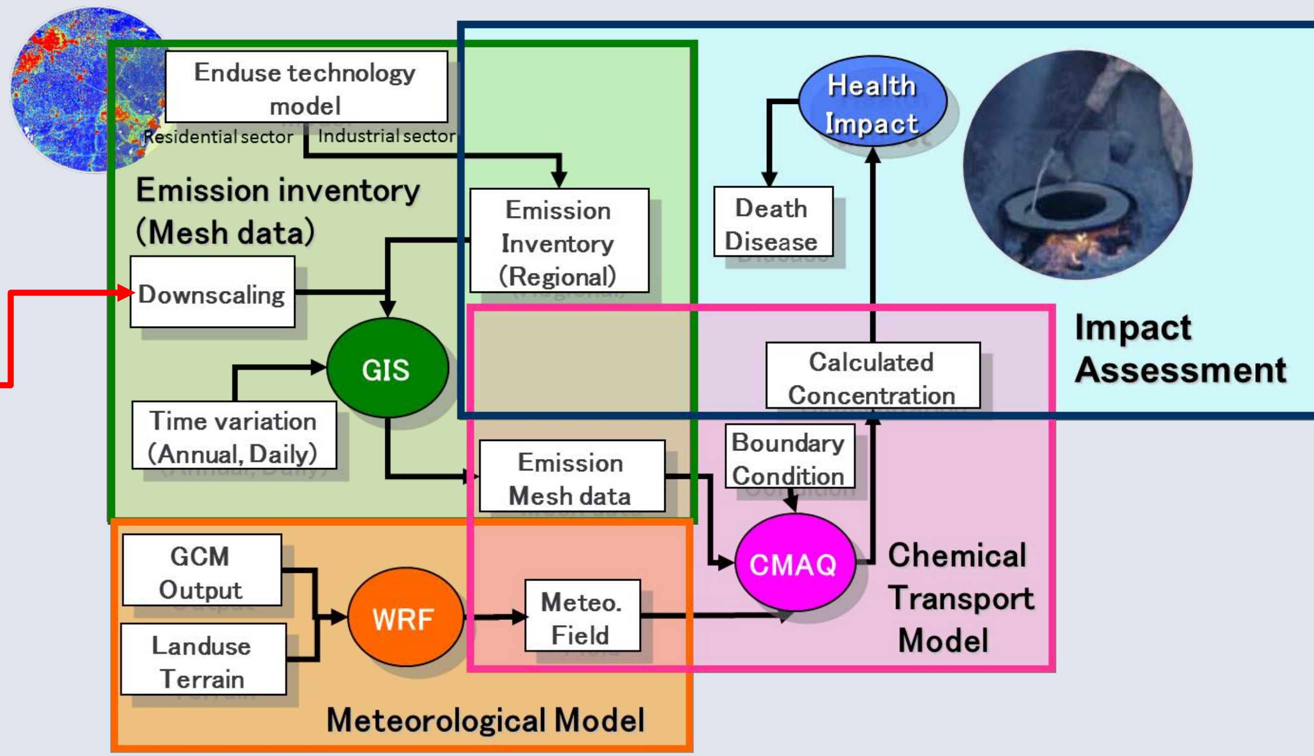
Estimated from ExSS Model



Estimated GHG reduction by each LCS actions

Model description





Meteorological Model

- WRF 3.4.1

  NCEP-FNL (1 degree, 6 hours)

  Noah land-surface model

  WSM 3-class simple ice scheme

Chemical Transport Model

- CMAQ 5.0.1

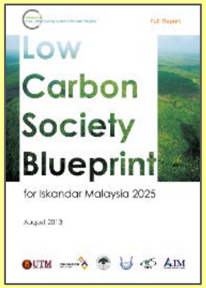
  Chemistry: SAPRC-99 - AERO5

  Boundary condition : MOZART4

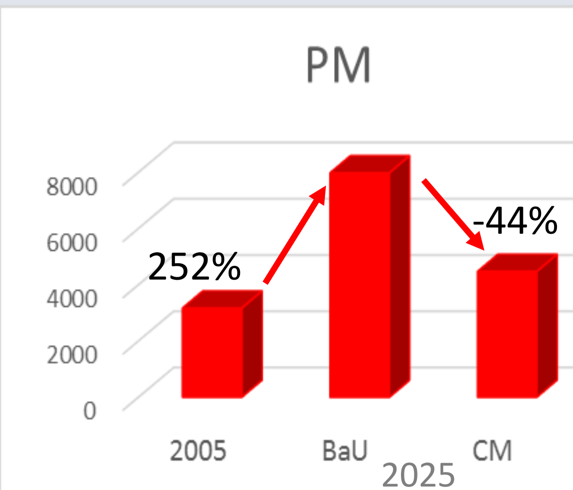
  Biogenic Emission: MEGAN

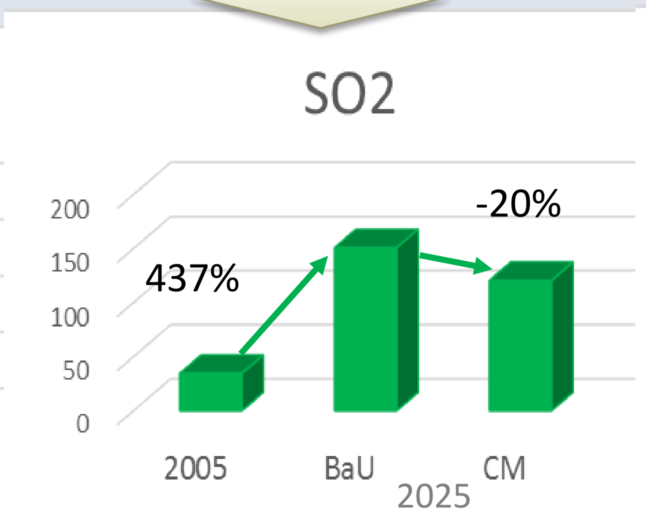
Reduction of Regional Emission

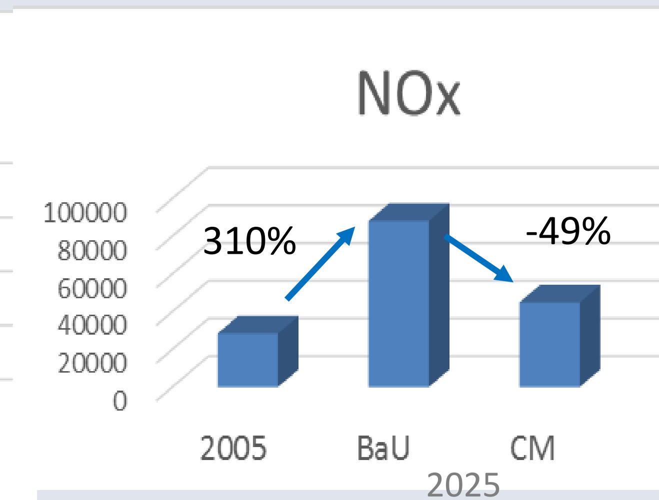
LCS Policies



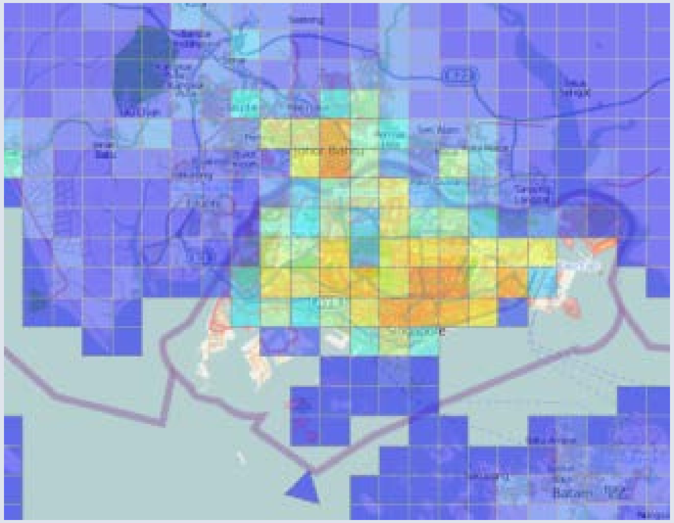
1: Green Transportation
2: Green Industry
3: Low Carbon Urban Governance
4: Green Building and Construction
5: Green Energy System
6: Low Carbon Lifestyle
7: Consensus Building
8: Walkable, Safe and Livable City Design
9: Smart Urban Growth
10: Green and Blue Infrastructure and Rural Resources
11: Sustainable Waste Management
12: Clean Air Environment



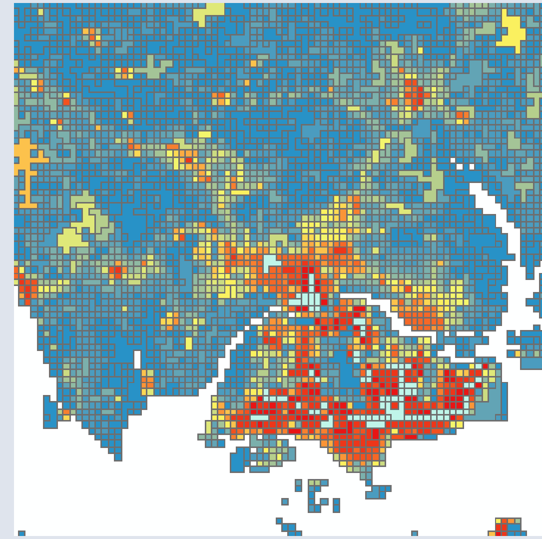


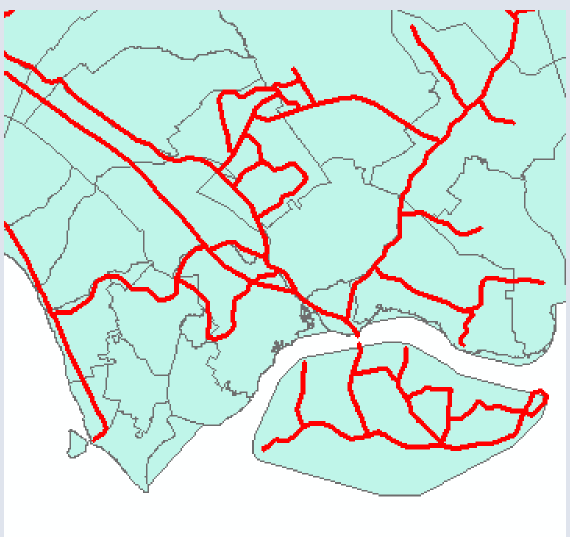


Improvement of GIS information for downscaling

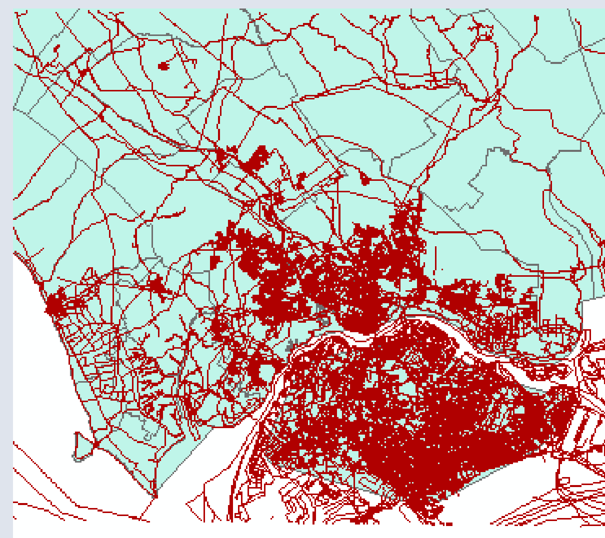


Population denstity
3km mesh → 1km mesh

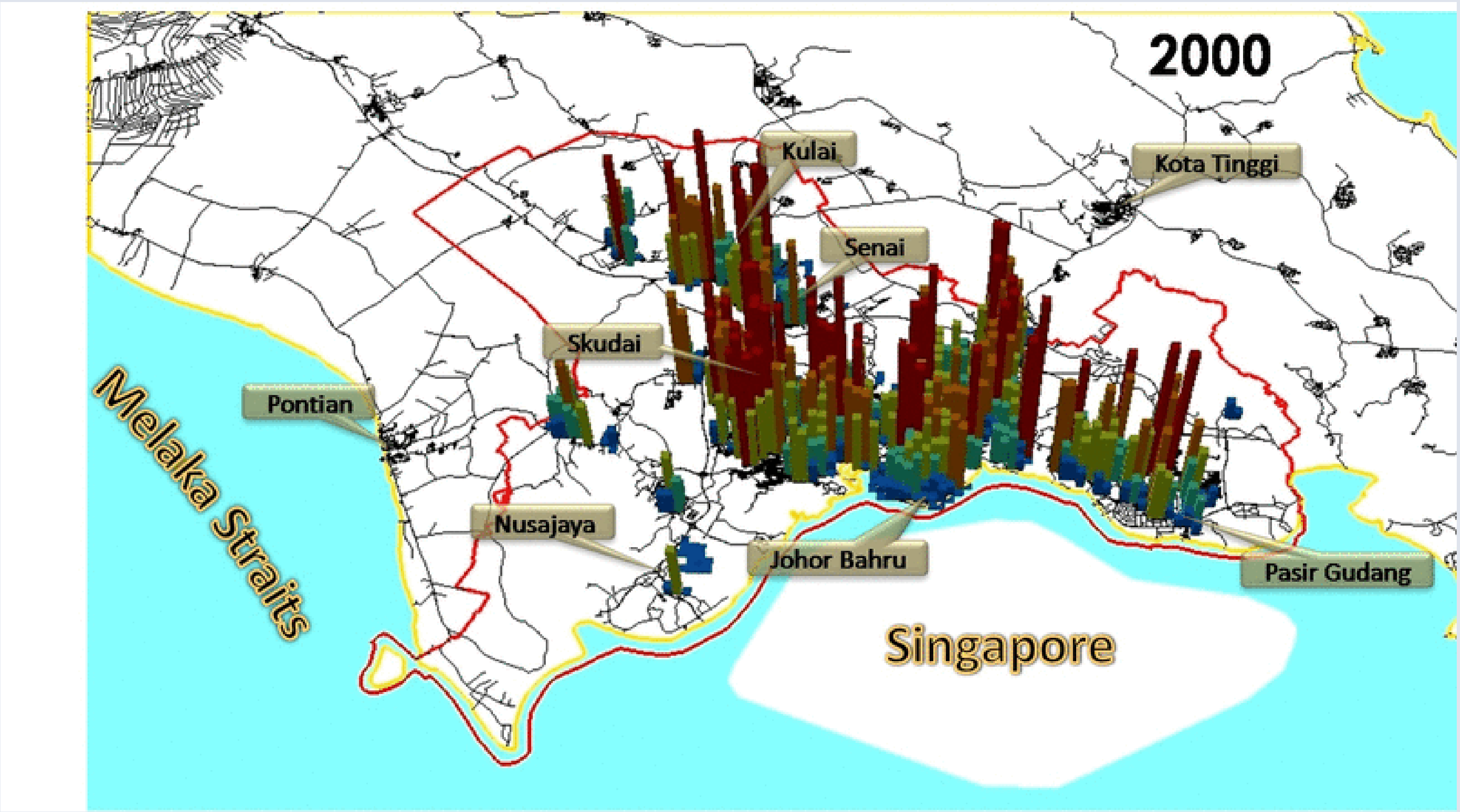




Road network

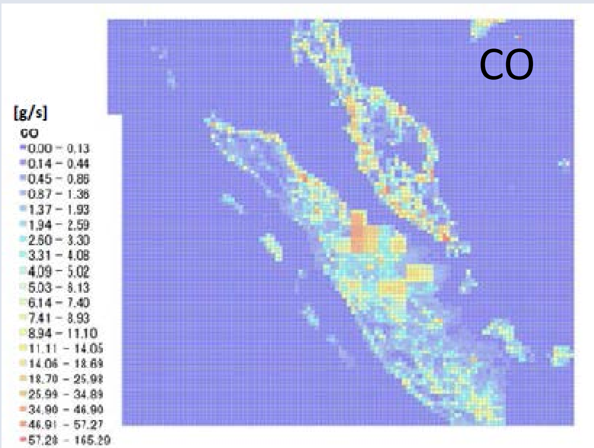


Estimation of Future Population distribution

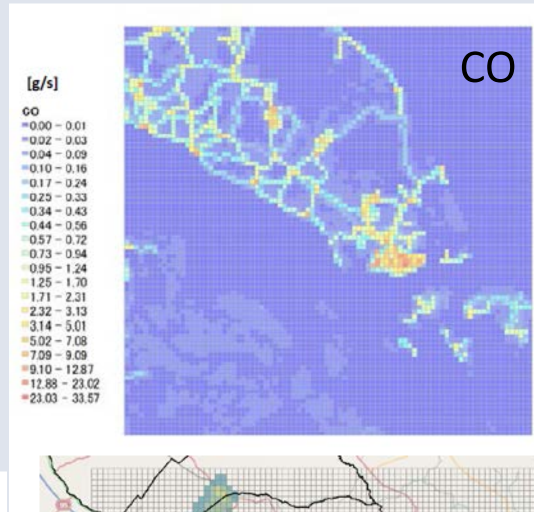


Regional Air Quality Simulation

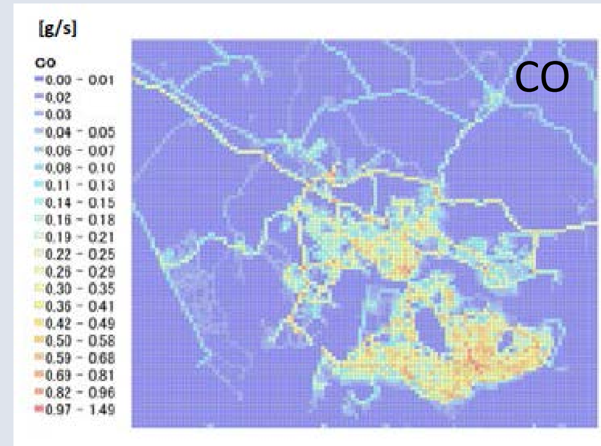
Domain 1

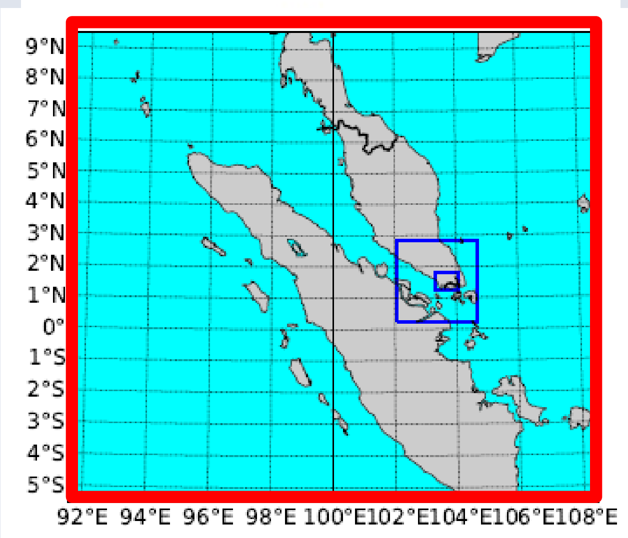


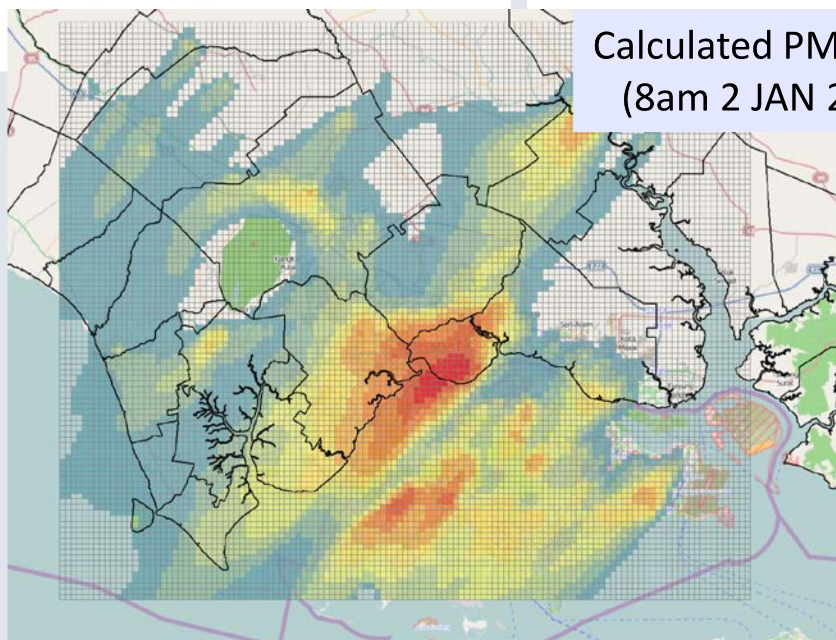
Domain 2



Domain 3

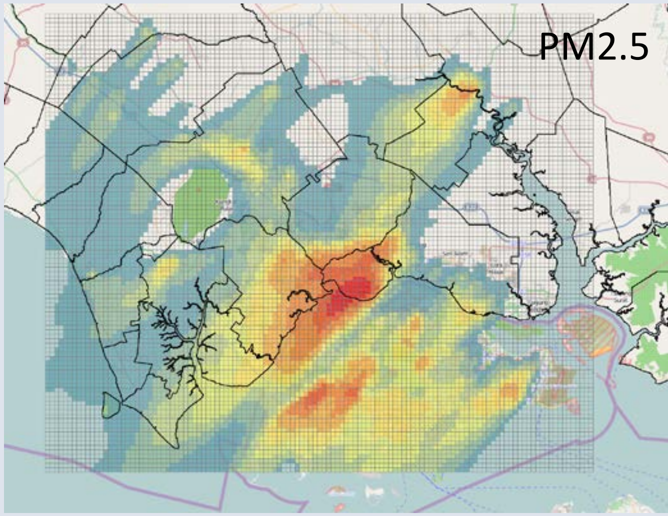




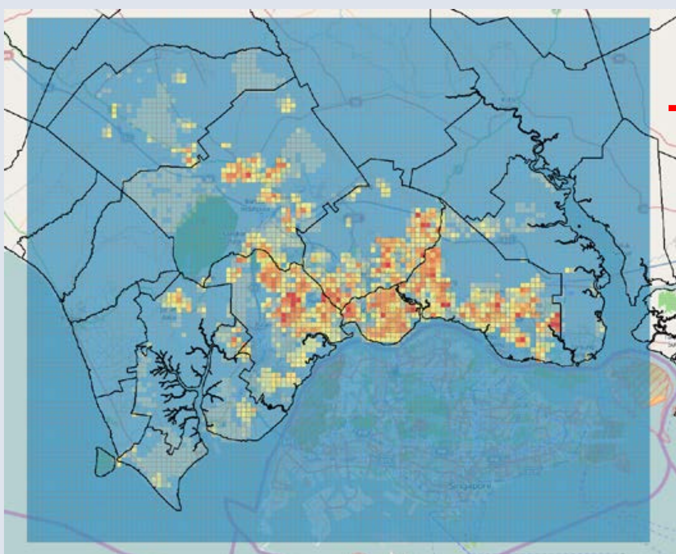


Calculated PM2.5 Concentration (8am 2 JAN 2013)

Health impact



Population density (2010 and 2025)



Methodology used by the Global Burden of Disease (WHO, 2004)

$$\Delta RR = \exp\left(\beta \times \underline{\Delta C}\right)$$

$$\Delta AP_k = (\Delta RR - 1) \div \Delta RR$$

$$E = \Delta AP \times f \times \underline{P}$$

where,

ΔRR : Change of Relative Risk

β: Relative risk coefficient

ΔC: Change of $PM_{2.5}$ concentration from base state

ΔAP: Change of attributable proportion for health endpoint

E: Number of cases of death attributed to air pollution

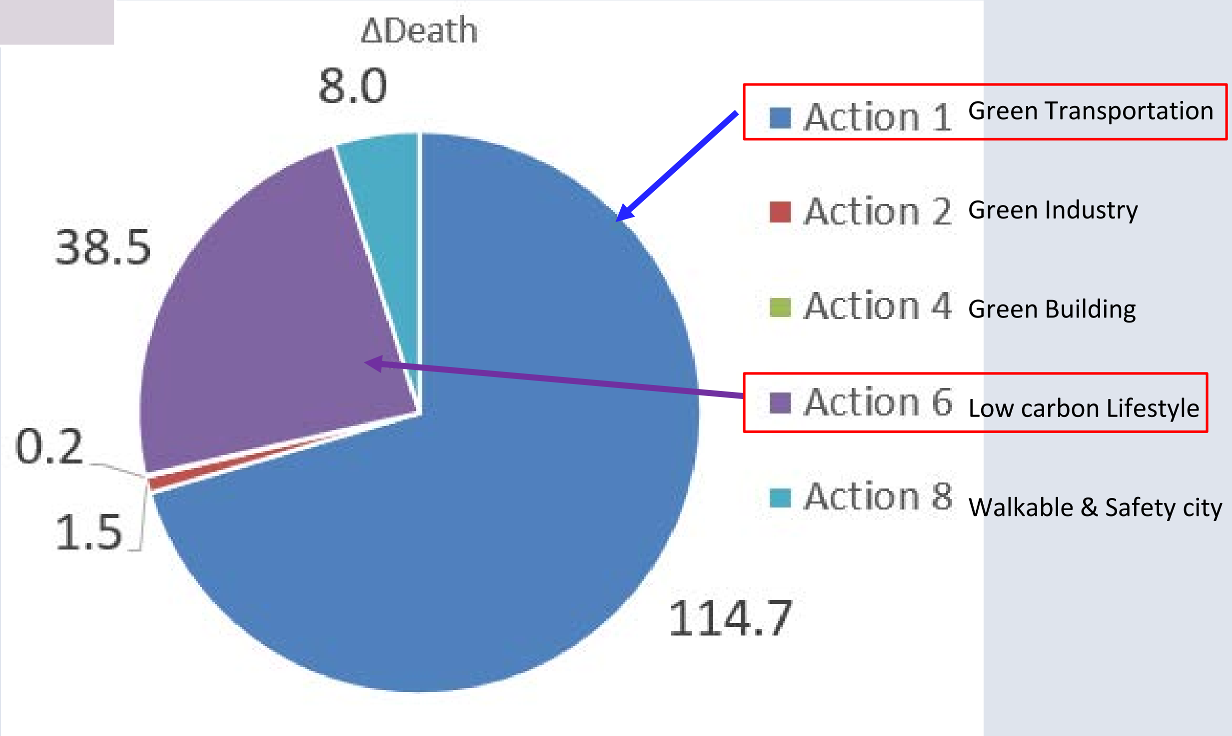
f: all cause mortality rate

Health impact

results [Whole IM region]

Case	N. of Death [person/year]
population in 2015 Base conc.	345
Population in 2025 BaU case conc.	417
Population in 2025 CM case conc.	254

Reduced premature death (Δ=163) by each actions



Summary

- By using WRF/CMAQ and Health impact equations, we estimated the reduction of premature death by urban PM2.5 pollution on each LCS countermeasures.
- In the case of Iskandar Malaysia, LCS Policy on public transportation have largest co-benefits on air quality.

Thank you for your attention