Estimation Methods for Carbon Emission Based on Data Availability on the Specific Regency or City in the Developing Countries

by :

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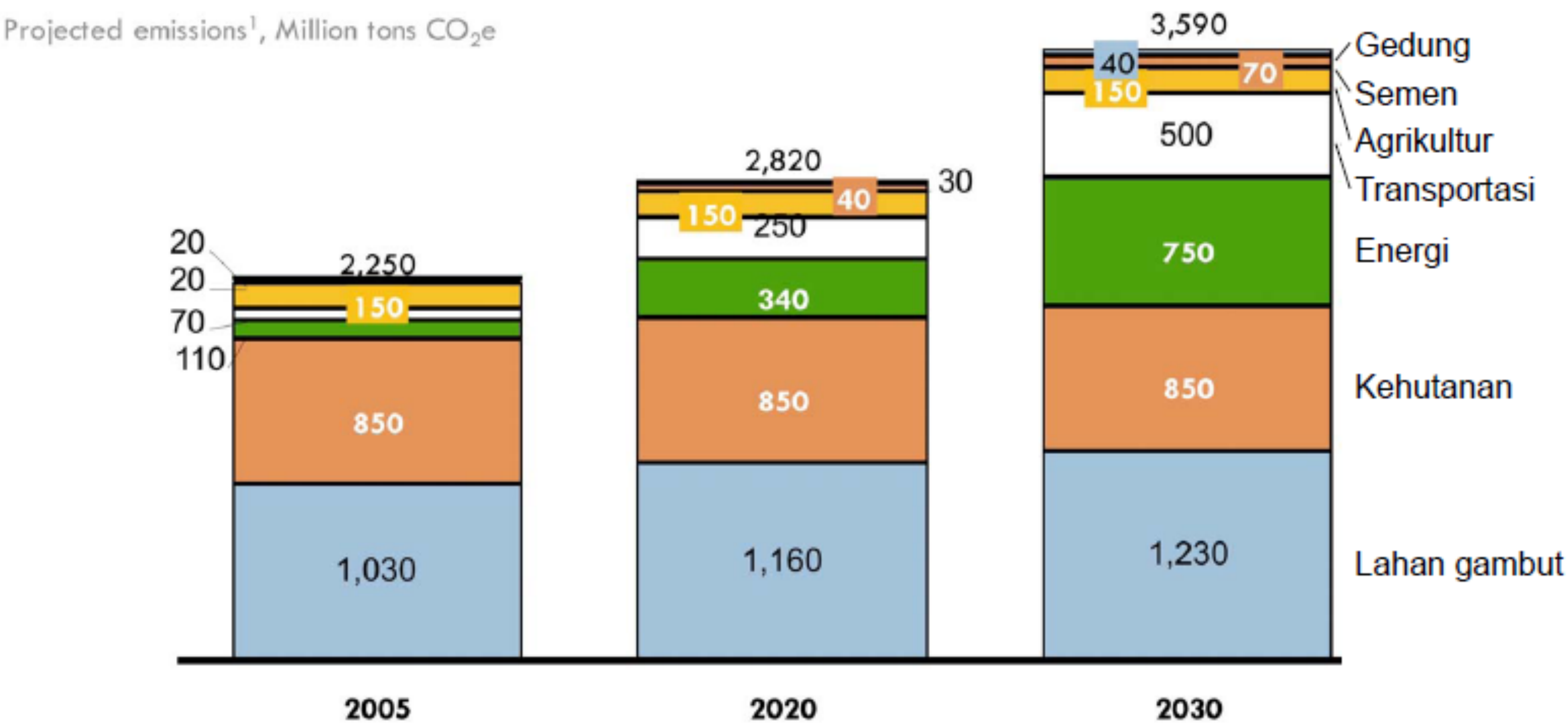
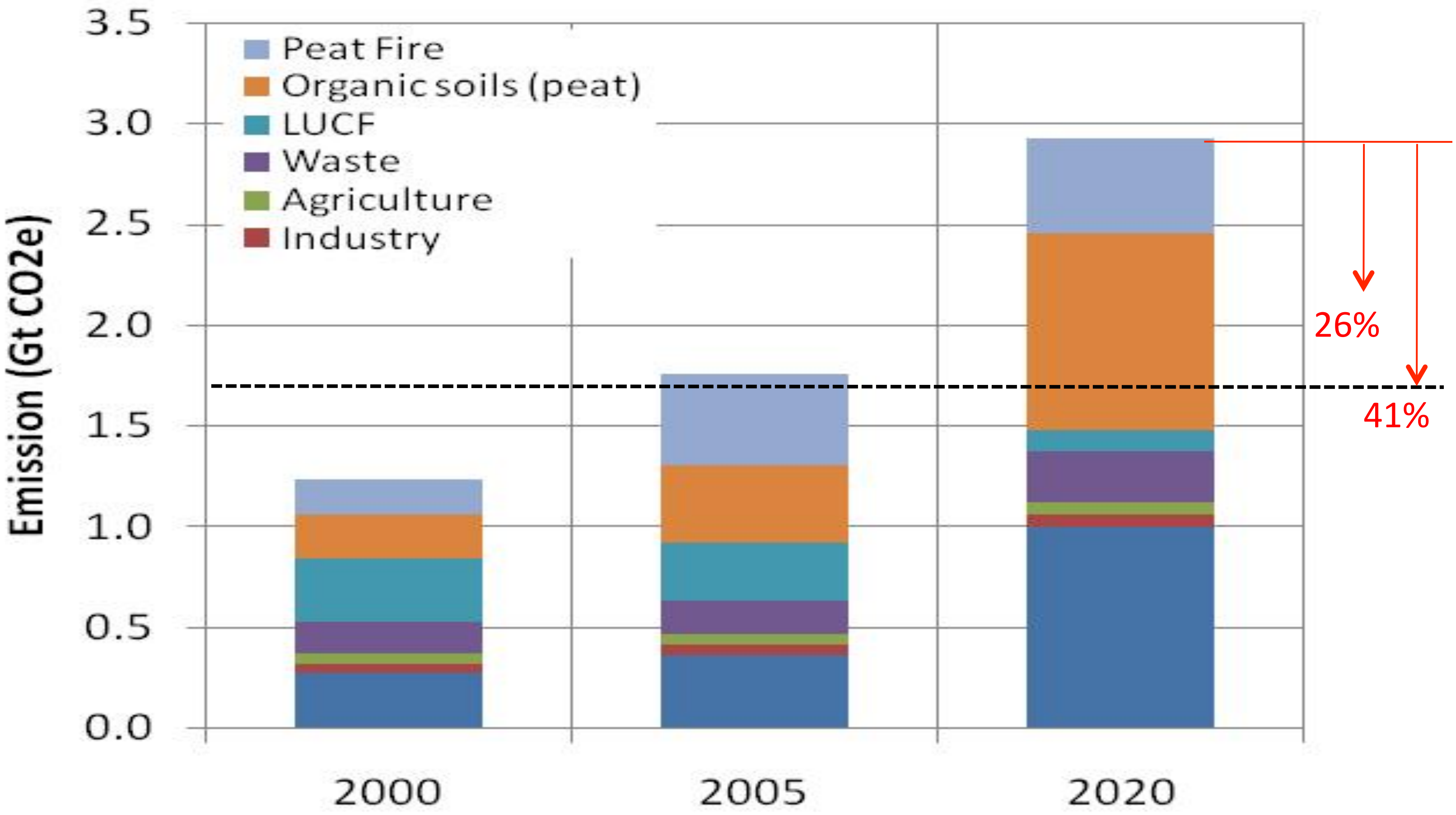
Current Issues of Carbon Emission in Indonesia

Emisi Indonesia diperkirakan meningkat dari 2.3 Gt menjadi 3.6 $GtCO_2e$ antara tahun 2005 dan 2030



Perbandingan emisi Indonesia terhadap emisi global

National Policy for GHG Reduction 26% & 41% In 2020



Source: SNC (2010)

(Dida Migfar Ridha, 2013)

Summary of GHG Emission in Indonesia 2000-2005 (Gg)

	2000	2001	2002	2003	2004	2005
Energy	280,937.58	306,774.25	327,910.62	333,950.21	372,123.28	369,799.88
Industrial Process	42,813.97	49,810.15	43,716.26	47,901.63	47,985.20	48,733.38
Agriculture	75,419.73	77,500.80	77,029.94	79,828.80	77,862.54	80,179.31
LUCF	649,254.17	560,546.00	1,287,494.79	345,489.33	617,423.23	674,828.00
Peat Fire	172,000.00	194,000.00	678,000.00	246,000.00	440,000.00	451,000.00
Waste	157,327.96	160,817.76	162,800.37	164,073.89	165,798.82	166,831.32
Total with LUCF&Peat fire[1]	1,377,753.41	1,349,448.96	2,576,951.98	1,217,243.86	1,721,193.07	1,791,371.89[2]
Total without LUCF&Peat fire	556,499.24	594,902.96	611,457.19	625,754.53	663,769.84	665,543.89

Sumber: Indonesia Second National Communication revised

(Dida Migfar Ridha, 2013)

Challenge of GHG Inventory: Uncertainty

No.	Source/Sink Categories	Current Uncertainty		Improved	
		AD	EF/RF	AD	EF/RF
1	Energy and transportation	10	5	Same	Same
2	Industry1	10	10	Same	Same
3	Agriculture	15	30	Same	Same
4a	Change in forest and other woody biomass	25	50	15	25
4b	Forest and grassland conversion	30	75	15	25
4c	Abandonment of managed land	25	50	Same	Same
4d	Soil emissions	50	75	Same	Same
4e	Peat burning (van der Werf et al. 2008)	25	50	15	25
5	Waste	50	50	Same	Same

Note: [1]The level of uncertainty for sub-categories of industrial process varied from 5 to 15 while for other sectors were assumed to be the same. AD = activity data; EF/RF = emissions factor/removal factor

Sumber: Indonesia Second National Communication (2010)

(Dida Migfar Ridha, 2013)

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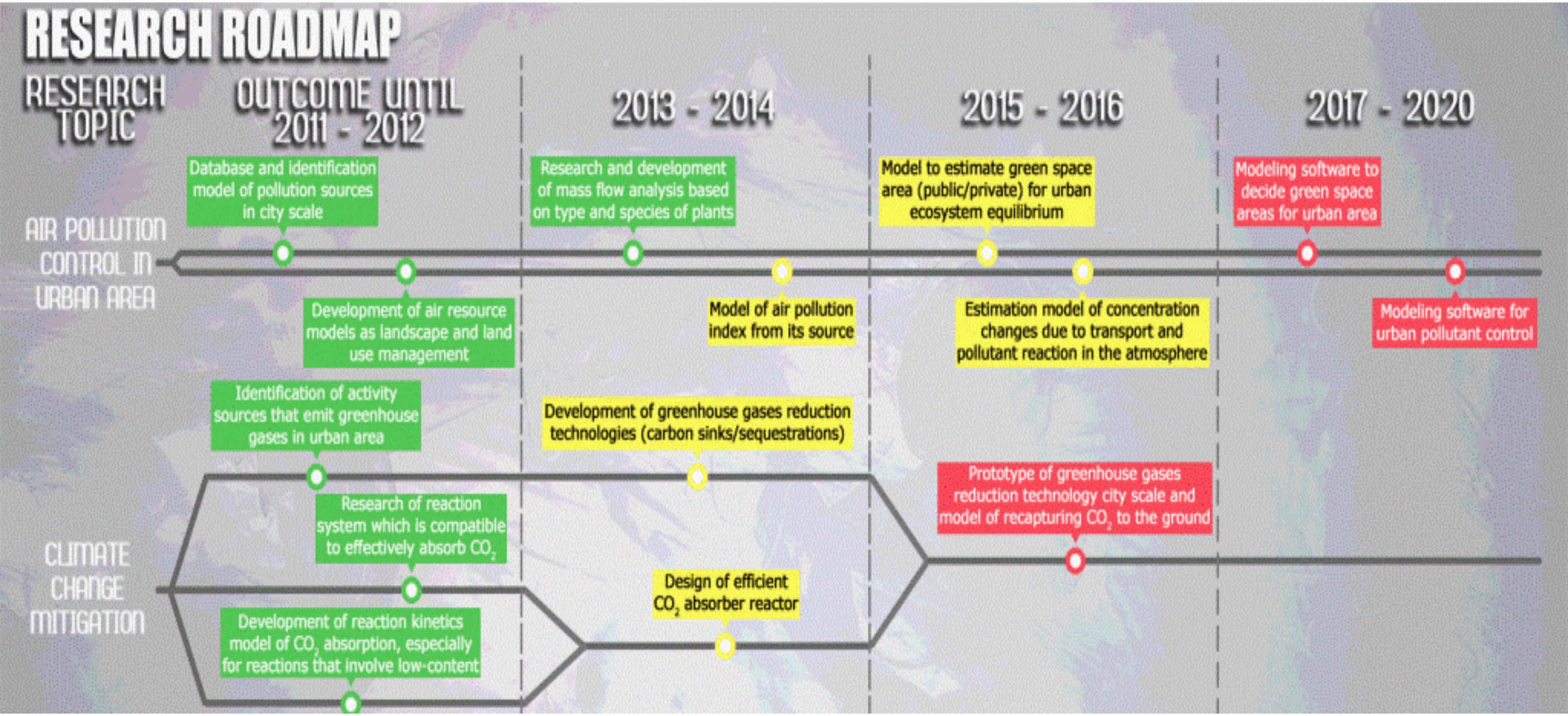

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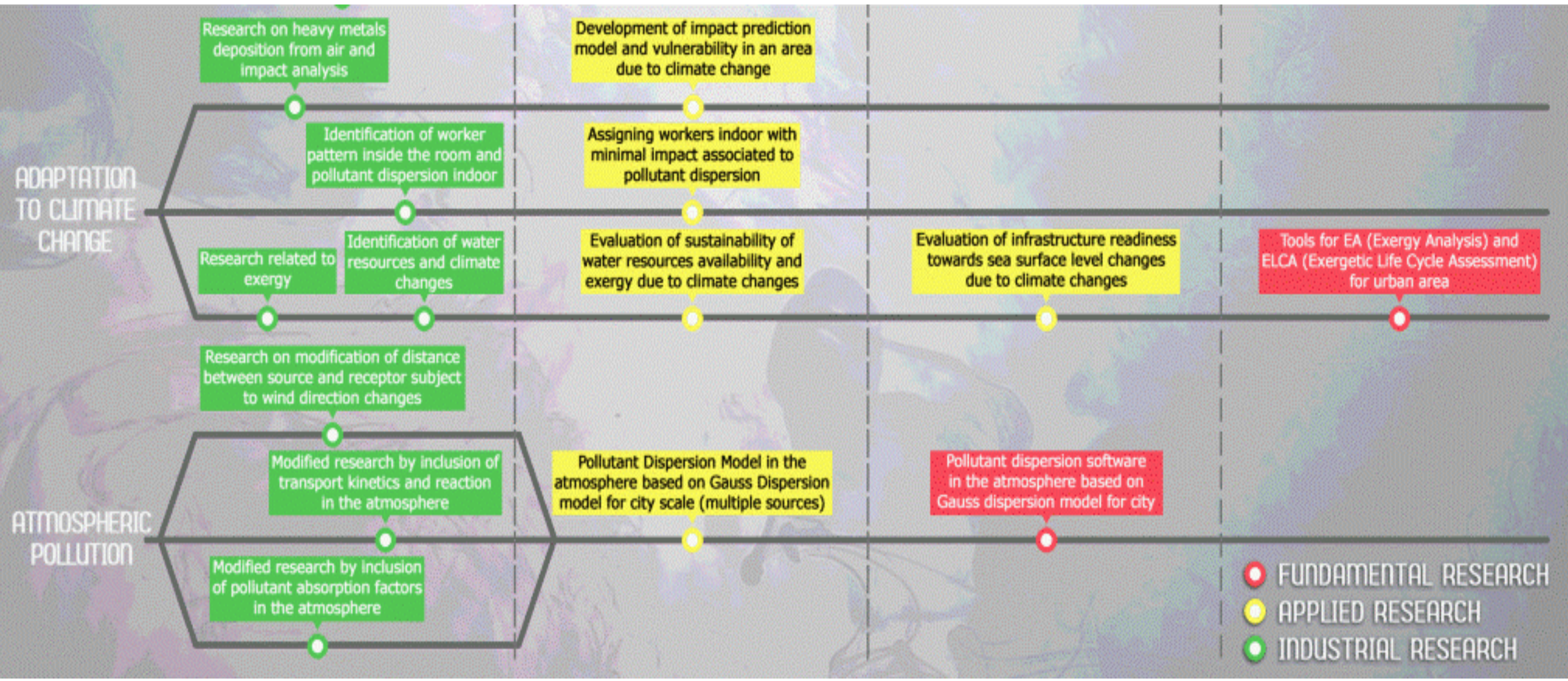

Main Goal

To develop methods that are simple to be applied for the regencies or cities based on the data availability and its regional development characteristics, particularly in developing countries.

Difficulties to estimate the carbon emissions:

There are mainly caused by;

1) the data availability that is not suitable with the IPCC model input,
2) the living styles that determine different emission characteristics.

Study Locations

The proposed SEF alternatives were then used to calculate the carbon emission in four different regional development zones, namely:

1) Industrial development zone,
2) educational/tourism development zone,
3) agricultural development zone, and
4) coastal/fishery development zone.

Review on Carbon Footprint Methods

The Primary Footprint

The Secondary Footprint

2

Review on Carbon Footprint Methods

Energy Consumption Reached 851 million BOE (Indonesian Environmental Status, 2008)

96%

The transportion sector contributes 23% of total global CO_2 emissions. Overal contribution of these emissions, 75% by road transport (Regmi & Hanaoka, 2011)

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Review on Carbon Footprint Methods

How to handle this problem ?

Calculation Method of The IPCC, 2006.

One part of the handling CO_2 emission is by conducting the emissions inventory in each region, to support the mapping and the management of national emissions programs

Review on Carbon Footprint Methods

The general approach for the measurement of CO_2 of emissions, are generally divided into two approaches (McKinno) :

Measurement based on Inputs (INPUT-BASED)

This approach is essentially a top-down measurement

Measurement based on Output (OUTPUT-BASED)

This is a bottom-up approach.
It usually gives a more accurate better estimation results

REVIEW OF ESTIMATION METHODS

$$Emision\ of\ CO_2 = \sum_{i=1}^{n} EF_i x\ Activity_i$$

Models emissions are classified into three equation principles. The equations include:

1. The calculation based on the quantity of fuels
2. The calculation based on the quantity and type of contributor *(Jennifer and Ata, 2010)*
3. The calculation based on the methodology by the IPCC (2006)

Alternative 1 Method:

The calculation of CO_2 emissions using the amount of fuel consumed multiplied by the emission factor of the fuel type

$$Fuel\ Energy\ unit = \ fuel\ type\ x\ energy\ content$$

$$CO_2\ emission = \sum [Fuel\ Energy\ unit\ x\ emission\ factor]$$

Alternative 2 Method :

The calculation of CO_2 based on the type of vehicles that are grouped according to the types of fuel, respectively

$$Vehicle\ fraction = \frac{Sum\ of\ Specific\ Vehicle}{Total\ of\ all\ type\ Vehicle}$$

$$ER_n = [emission\ factor\ x\ vehicle\ fraction]$$

$$e = [\sum_{n=1}^{N}(TG_n x O x ER_n)]$$

$$Specific\ fuel\ consumption = \frac{fuel\ comsumption\ (litre)}{amount\ of\ specific\ vehicle\ (unit)}$$

$$CO_2\ emission = \sum[e\ x\ Specific\ fuel\ consumption]$$

IPCC Method 3:

This method provides a three-TIER approach for different degree of accuracy in accordance with the specification of the data availability. The higher TIER gives better accuracy, but requires more complex of data and procedures

Tier 1 methodology

$$CO_2\ emission = \sum (\mathrm{Fuel}_a \mathrm{x\ EF}_a)$$

Tier 2 methodology

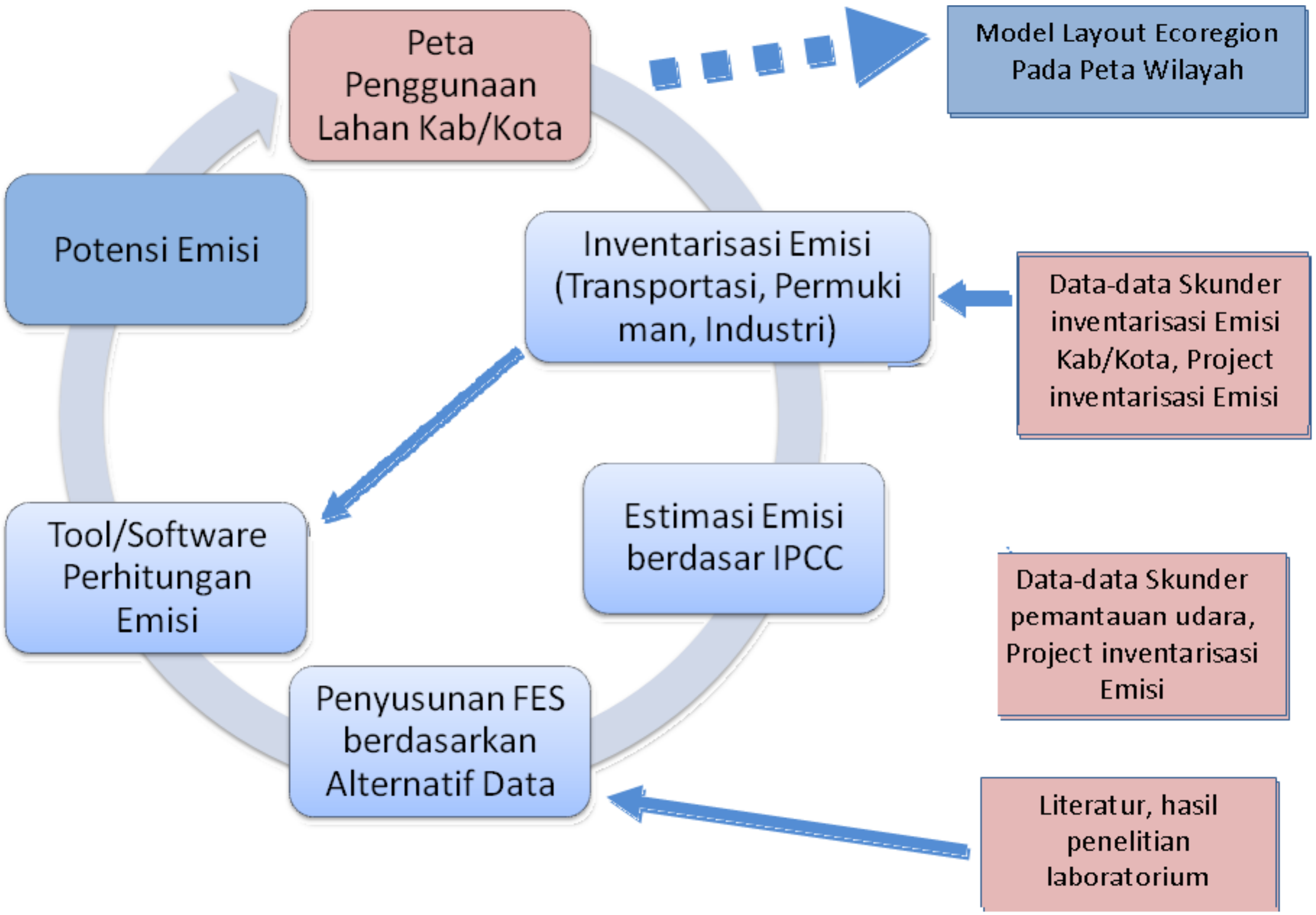
Equation in Tier 1 can applied for Tier 2, with emission factors must be calculated based on actual fuel carbon content.

Tier 3 methodology

- Tier 3 is more accurate than the Tier 1 and Tier 2
- But the calculation of CO_2 emissions by the IPCC Guidelines is recommended only using Tier 1 and Tier 2

(Eggleston, 2006)

Study Approach

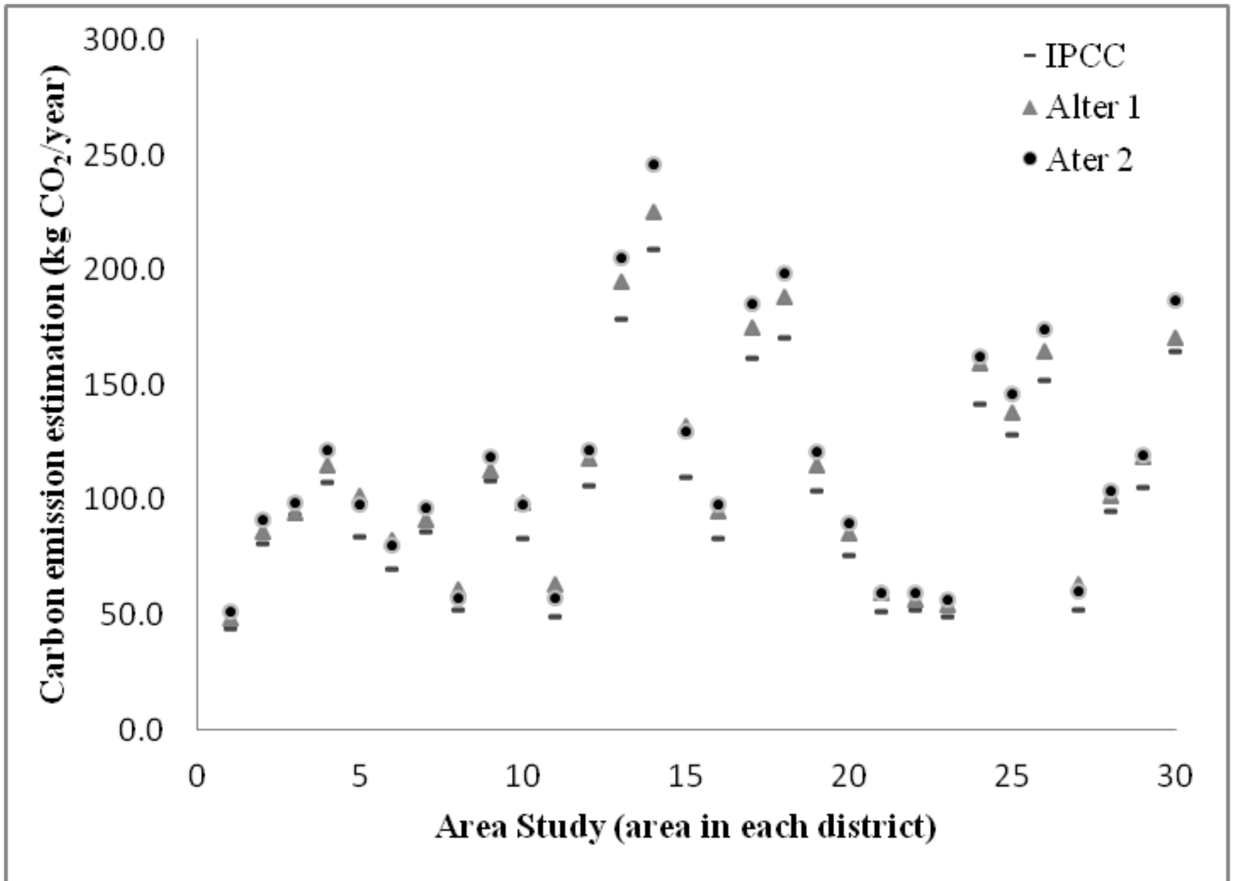


Comparison Methods

Sector	IPCC 2006	Our Study
Transportation	Fuels Consumption Vechicle types	Road classification
Industry	Fuels Consumption	Industry Equivalent
Human Settlements	Fuels Consumption NCV (Net Calorific Values)	Housing types Number of inhabitants House Equivalent

RESULTS AND DISCUSSION

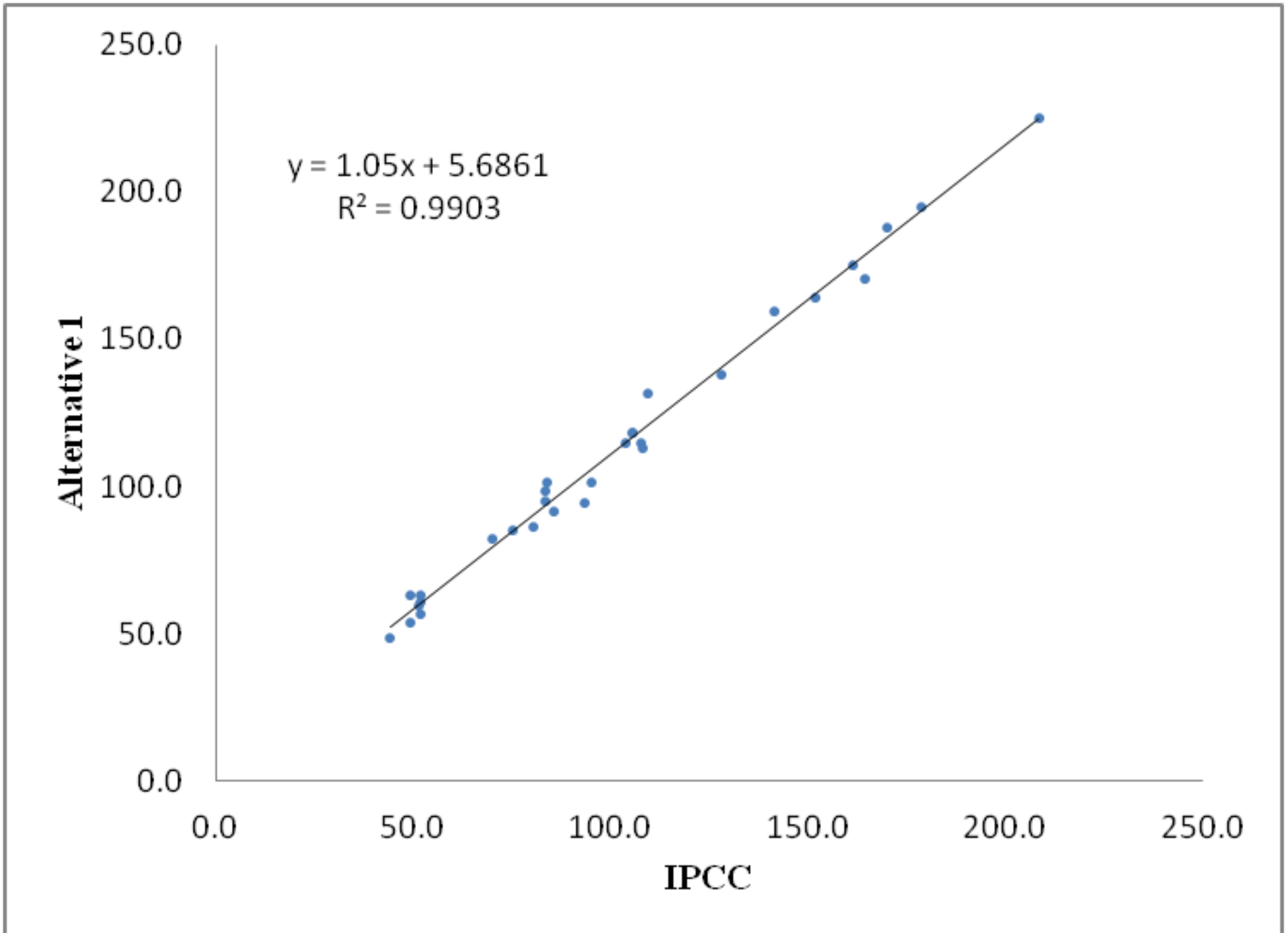
Figure 1. Carbon Emissions Estimation for the Transportation Sector



In general, Figure 1 shows the values generated by the two alternative methods tend to result in **higher emission** values **from the IPCC**. However, these values are **consistent and fairly close to each other**

RESULTS AND DISCUSSION

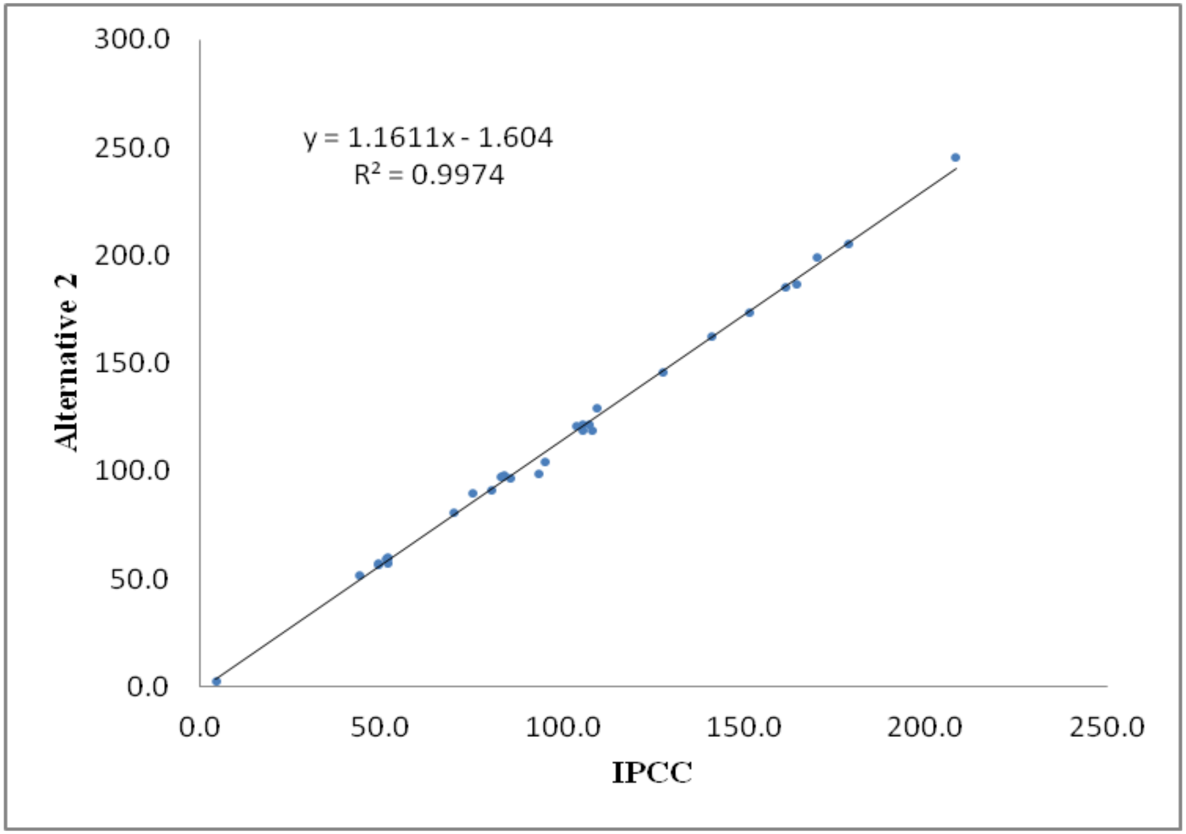
Figure 2. Correlation of Alternative 1 Emission Calculation Results to IPCC Estimate



It appears that both values are in the same tendency or **linear correlation**. Value of correlation (R^2) for alternative 1 and the IPCC is 0.990.

RESULTS AND DISCUSSION

Figure 3. Correlation of Alternative 2 Emission Calculation Results to IPCC Estimate

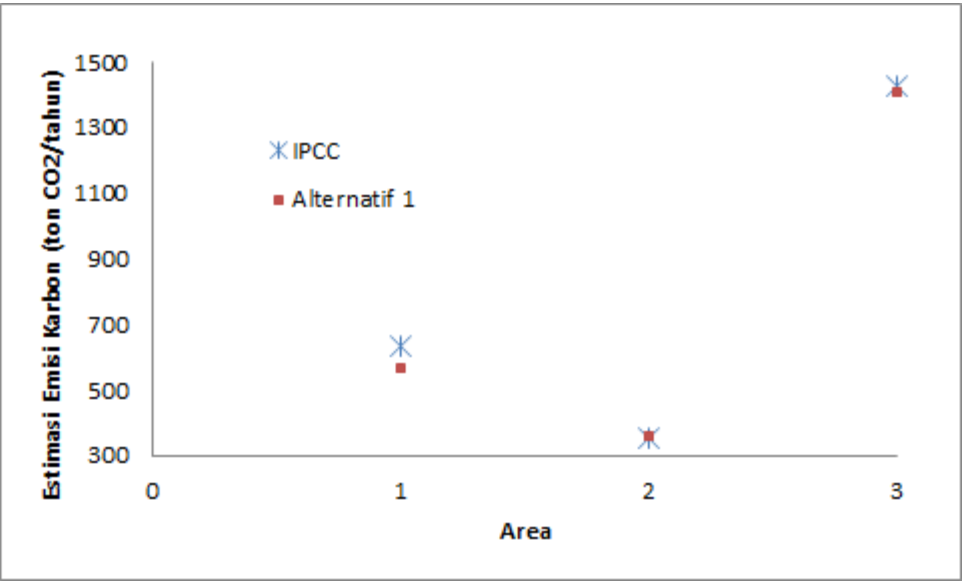


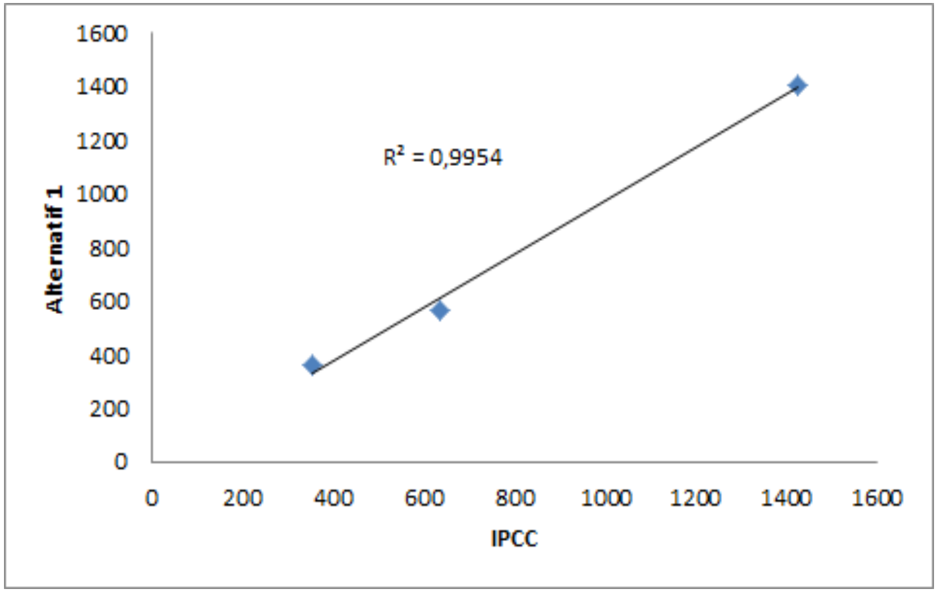
The calculation to standard error of the two alternative data correlation with the IPCC gives the following results:

- Alternative 1 provides the results of 112.3 ± 4.7 kg CO_2/year
- Alternative 1 provides the results of 116.3 ± 2.8 kg CO_2/year

RESULTS AND DISCUSSION

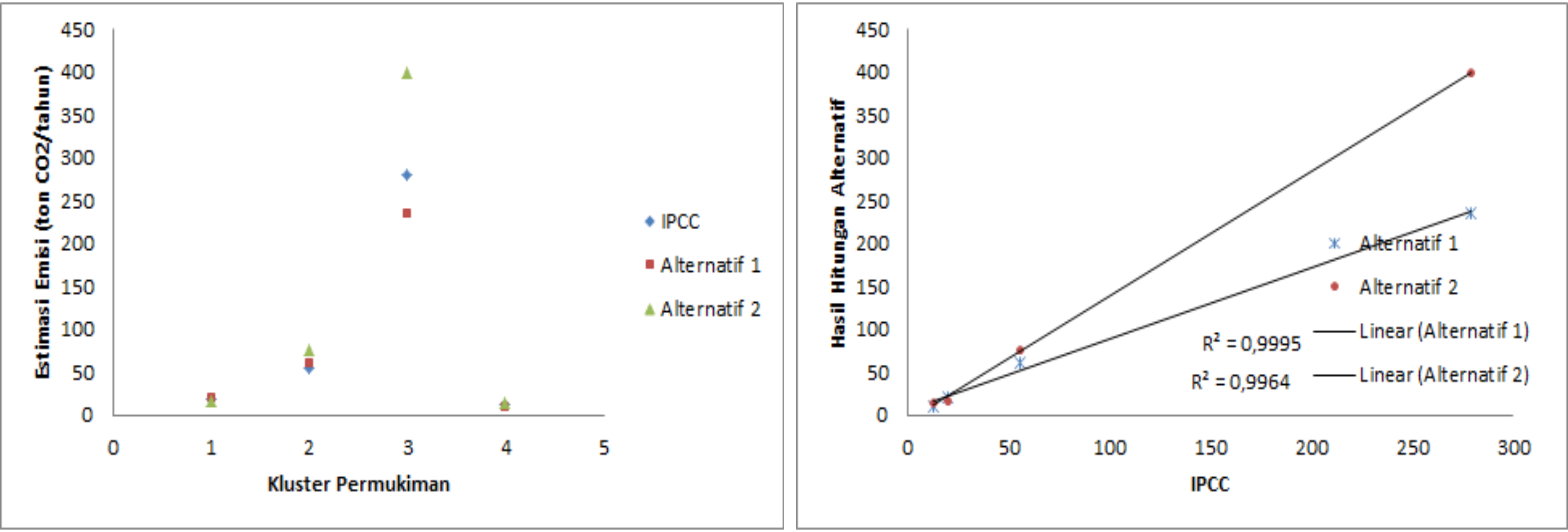
Figure 3. Carbon Emission Estimation and its Correlation to IPCC Methods (Industry Sectors)





RESULTS AND DISCUSSION

Figure 3. Carbon Emission Estimation and its Correlation to IPCC Methods (Human Settlement Sectors)



Balances of Carbon Emission

Regions/ City Zone	Transporta-tion	Industry	Settlements	Emission Total	Green Space
			(tonCO_2/year)		
Industrial	388.979,04	21.848	342.278	753.105,04	-4.998.402
Education/ Tourism	522.961	7.313	54.425	584.699	-135.205
Agricultural	19.343	4.622	102.440	126.405	-31.317.664
Fishery/ Coastal	536.864	-	148.659,1	685.523,1	-152.120.434

Balances of Carbon Emission

Regions/City Zone	Emission Balance	Population	FES
	tonCO_2/year	*Cap*	*tonCO_2/cap.year*
Industrial	-4.245.297	1.984.486	-2,14
Education/ Tourism	449.494	820.243	0,55
Agricultural	-31.191.259	1.078.315	-28,85
Fishery/ Coastal	-151.435.000	1.564.833	-96,77

Conclusions

- The calculation of carbon emissions (tons CO_2/year) and specific carbon emissions (tons CO_2/person.year) for the four regional developmental zones were sequentially noted as follows:
  1. - 4,245,297 and - 2.14 (Industrial development zone)
  2. 449,494 and 0.55 (Educational/tourism development zone)
  3. - 31,111,259 and - 28.85 (Agricultural development zone)
  4. - 151,435,000 and - 96.77 (Coastal/fishery development zone)

Conclusions

- The alternative methods for calculating carbon emissions can be applied during the limited availability of existing data in a regency/city in the developing country, which is comparable with the IPCC methods.
- The verified SEF for transportation, industry and human settlement activities yielded values that were closed to the IPCC calculation method, with the correlation factors of R^2 ~ 0.99 and 0.997 for transportation, R^2 ~ 0.995 for industry, and R^2 ~ 0.999 and 0.996 for human settlement.

THANK YOU