Chinese Site-Normalization References for Life Cycle Impact Assessment

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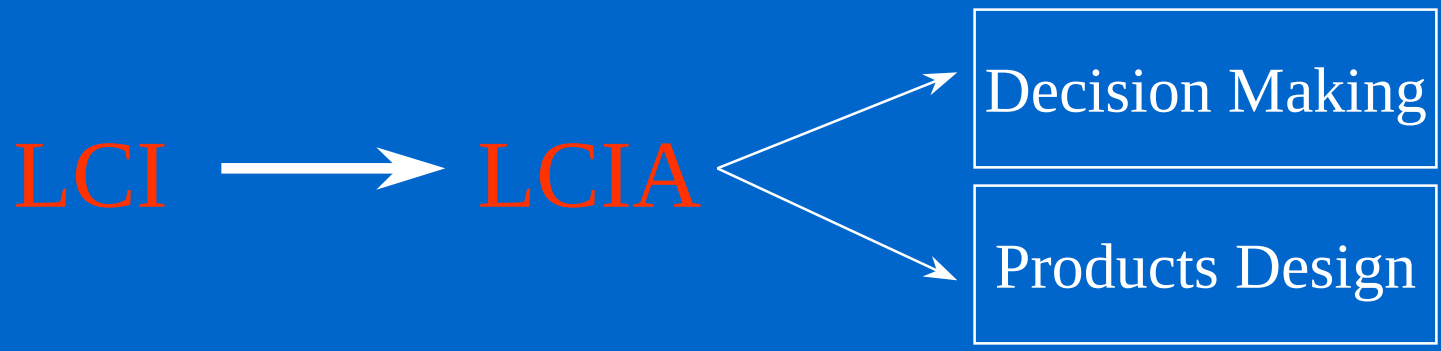
Background and objectives



- **Which environmental exchanges are significant?**
- **How great their contributions can be?**

Purposes of Normalization

- To provide an impression of the relative magnitudes of the potential environmental impacts and thus facilitate comparison of contributions to different impact categories.
- To present the results in a form suitable for the final weighting and decision-making.

Normalization in LCIA

The environmental impact potential of the emission =
emitted amount of substance * impact potential of substance

$$EP(j)_i = Q_i EF(j)_i$$

Total environmental impact potential:

$$EP(j) = \sum_i EP(j)_i = \sum_i (Q_i EF(j)_i)$$

$$NEP(j) = EP(j)/ER(j)_{90}$$

Normalization References(I)

EDIP Method

Total environmental impact potential
for the area in question in 1990 (EP(j)90)
divided by the population in the area in question.

$$ER(j)_{90} = EP(j)_{90}/Pop_{90}$$

$$EP(j)_{90} = \Sigma EP(j)_{i,\,90}$$
$$= \Sigma\,(Q(j)_{i,\,90} \times EF(j)_i)$$

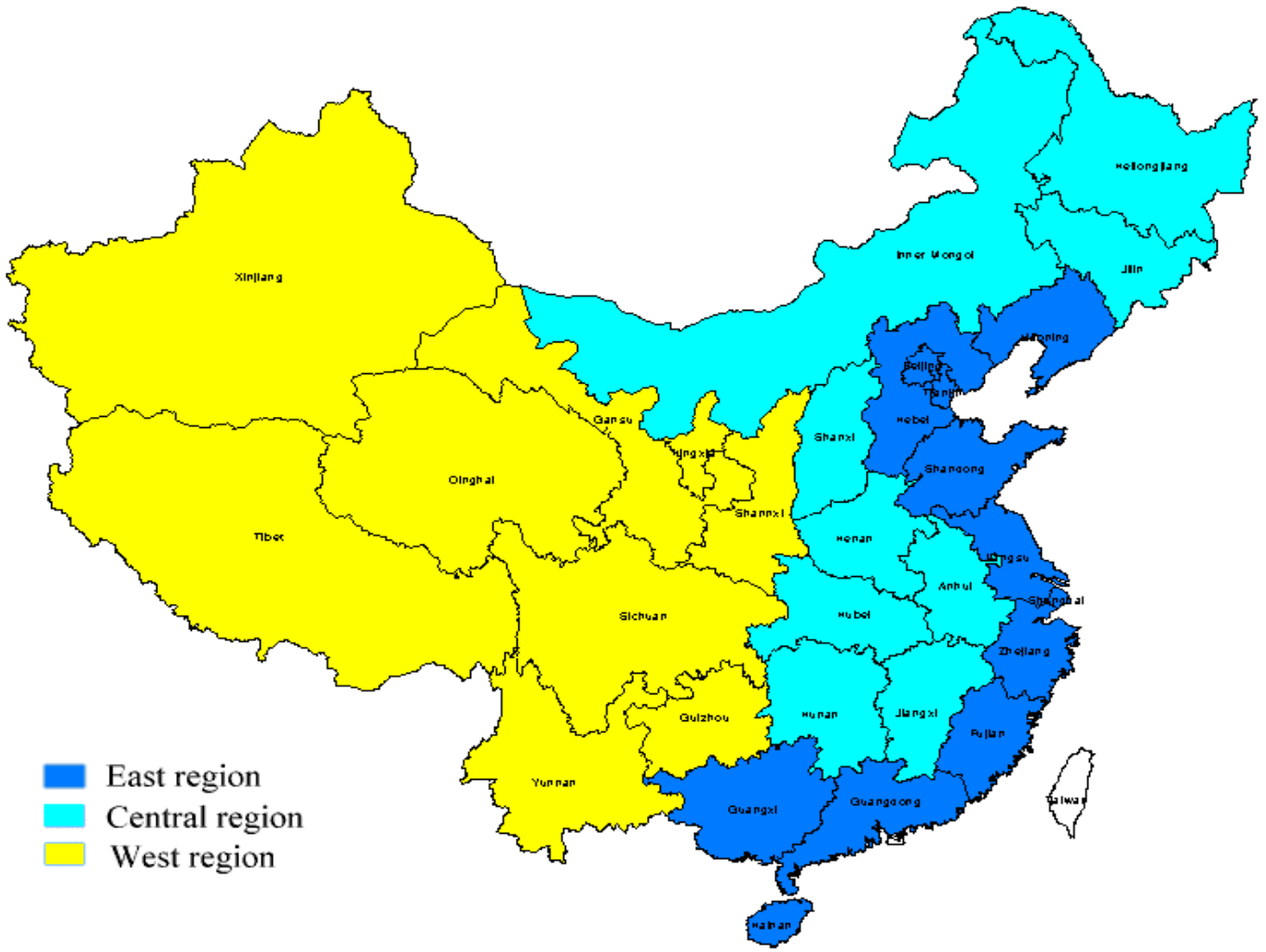
Unit: Person equivalents

NR for Acidification

	g SO_2-eq/ g compound	Total emissions kt/year	kt SO_2-eq /year
SO_x	1	17,932	17,932
NO_x	0.7	8,353	5,847
NH_3	1.88	8,918	16,767
Total			40,546

NR=40,546,000,000 kg/1,140,000,000 person=36 SO_2 eq./person.a

Three regions of China



Characteristics of three regions

	Eastern region	*Central region*	*Western region*
Industrial output intensity, %	69.2	21.7	9.1
Industrial enter-prises, %	55.7	29.9	14.4
Population, %	48.9	34.2	16.9
Provinces included	12	9	9

Source: China Statistical yearbook (1996)

Chinese data sources

- 30 Provinces
- Main sources for specific emissions, with average area level
- Aggregate them into three regions

Person-based Chinese NR

Impact category	*Normalization reference, ER_{90}*				*Normalization reference unit*
	East	*Central*	*West*	*China*	
Global warming	8,700				kg CO_2-eq/person/year
Ozone depletion	0.20				kg CFC11-eq/person/year
Acidification	35	33	41	36	kg SO_2-eq/person/year
Nutrient enrichment	57	60	67	61	kg NO_3-eq/person/year
Photochemical ozone formation	0.76	0.63	0.48	0.65	kg C_2H_4-eq/person/year
Bulk waste	291	247	186	251	kg bulk waste/person /year
Hazardous waste	22	17	15	18	kg hazard. waste/person/year
Slag and ashes	18	21	16	18	kg slag and ashes/person/year

http://ipt.dtu.dk/employ/pn.htm

Discussions on NR

- **Chinese NR is Lower than that of Danish**
  - **Lower industrialization and huge population**
- **Three regions analysis**
  - **No big differences between regions with most impact categories(the population density is ignored).**
  - **National or Eastern results suggested.**

Objective of Developing NR(II)

- To reflect the environmental impacts from product system at regional or local view.
- To help the LCA audience to understand the results easily.
- Combine the potential impacts and actual impacts at regional or local level.

Normalization References(II)

Total environmental impact potential
for the area in question in 1990 (EP(j)90)
divided by the territory area in question.

$$ER(j)_{90} = EP(j)_{90}/Area_{90}$$

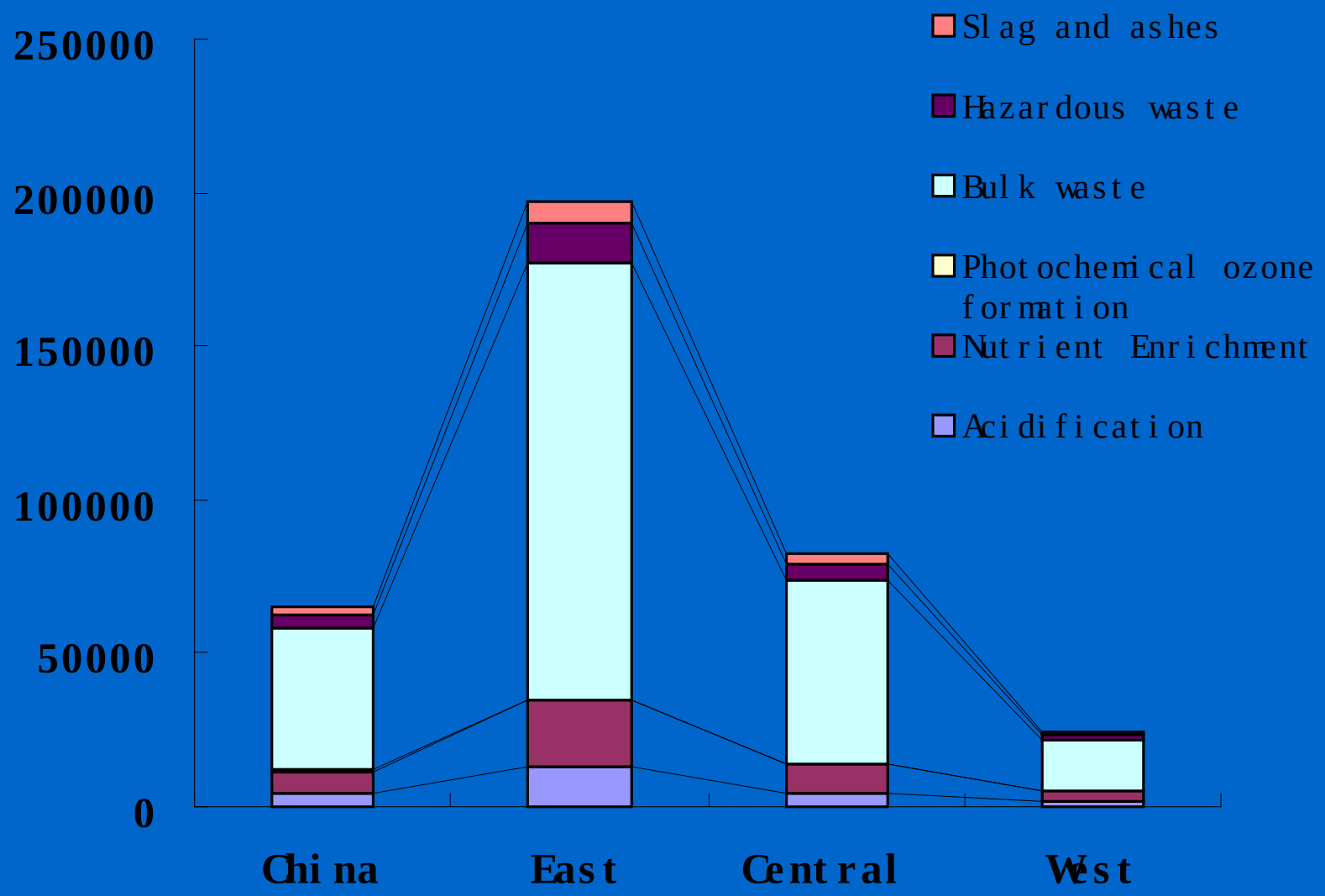
$$EP(j)_{90} = \Sigma EP(j)_{i,\,90}$$
$$= \Sigma\,(Q(j)_{i,\,90} \times EF(j)_i)$$

Unit: Km^2 equivalents

Area-based Chinese NR

Impact category	*Normalization reference, ER_{90}*				*Normalization reference unit*
	East	*Central*	*West*	*China*	
Global warming	337,898				kg CO_2-eq/km^2/year
Ozone depletion	8				kg CFC11-eq/ km^2/year
Acidification	12685	4735	1980	4252	kg SO_2-eq/ km^2/year
Nutrient enrichment	21631	8787	3338	7443	kg NO_3-eq/ km^2/year
Photochemical ozone formation	280	90	23	78	kg C_2H_4-eq/ km^2/year
Bulk waste	142679	60138	16393	46568	kg bulk waste/ km^2/year
Hazardous waste	12777	5495	1612	4284	kg hazard. waste/ km^2/year
Slag and ashes	6689	2929	751	2206	kg slag and ashes/ km^2/year

Regional NR comparison(Area)

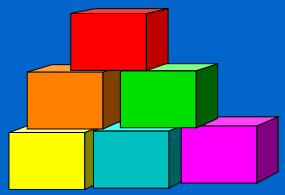


Site-NR discussions

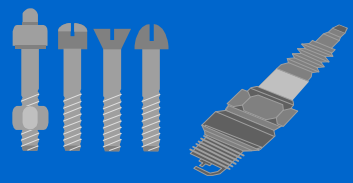
- Big differences between three regions
- The higher the industrialization level, the higher the NR is.
- Contrast between NR for local impacts is higher than that of regional impacts.

Xiali Car produced in China

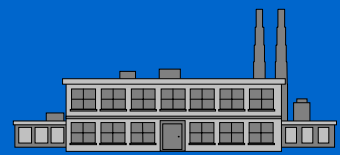
The system boundary



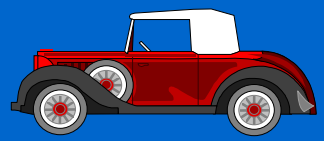
MAIN MATERIALS PRODUCTION



CAR COMPONENTS PRODUCTION



CAR ASSEMBLING



CAR USE PHASE

Assumptions

- Xiali Car was manufactured in the eastern region.
- Production and use of gasoline in the western region.
- Life span=12 years
- Only the regional impacts are analyzed

Normalization-Global Impacts

- **Global warming**
- **Ozone depletion**

Normalization references are globally valid

Air emissions from Xiali production

kg per car	Fuel Prod.	Fuel Use	Transport	Process	TOTAL
Dust	28.5	1.6	0.6	17.6	48.3
CO	12.1	5.1	0.5	71.3	89.0
CO_2	3618	3652	611	2757	10,638
SO_X	36.6	28.1	0.5	10.7	75.9
NO_X	16	10.2	0.2	3.1	29.5
Hydrocarbor	0.6	0.6	0.063	2.2	3.5
Methane	0.73	0.54			1.3
H_2S	3.80E-02			5.25E-02	0.0905
HCl	1.33E-02	0.3		6.50E-03	0.3198
HF	6.54E-04	2.30E-03		2.90E-05	0.002983
Lead		4.70E-03			0.0047
Metals	8.60E-05	1.10E-03		4.80E-04	0.001666
F2				0.376	0.376
Organo - Cl				2.47E-02	0.0247
Aromatic HC				4.76	4.76
H_2SO_4				3.90E-03	0.0039

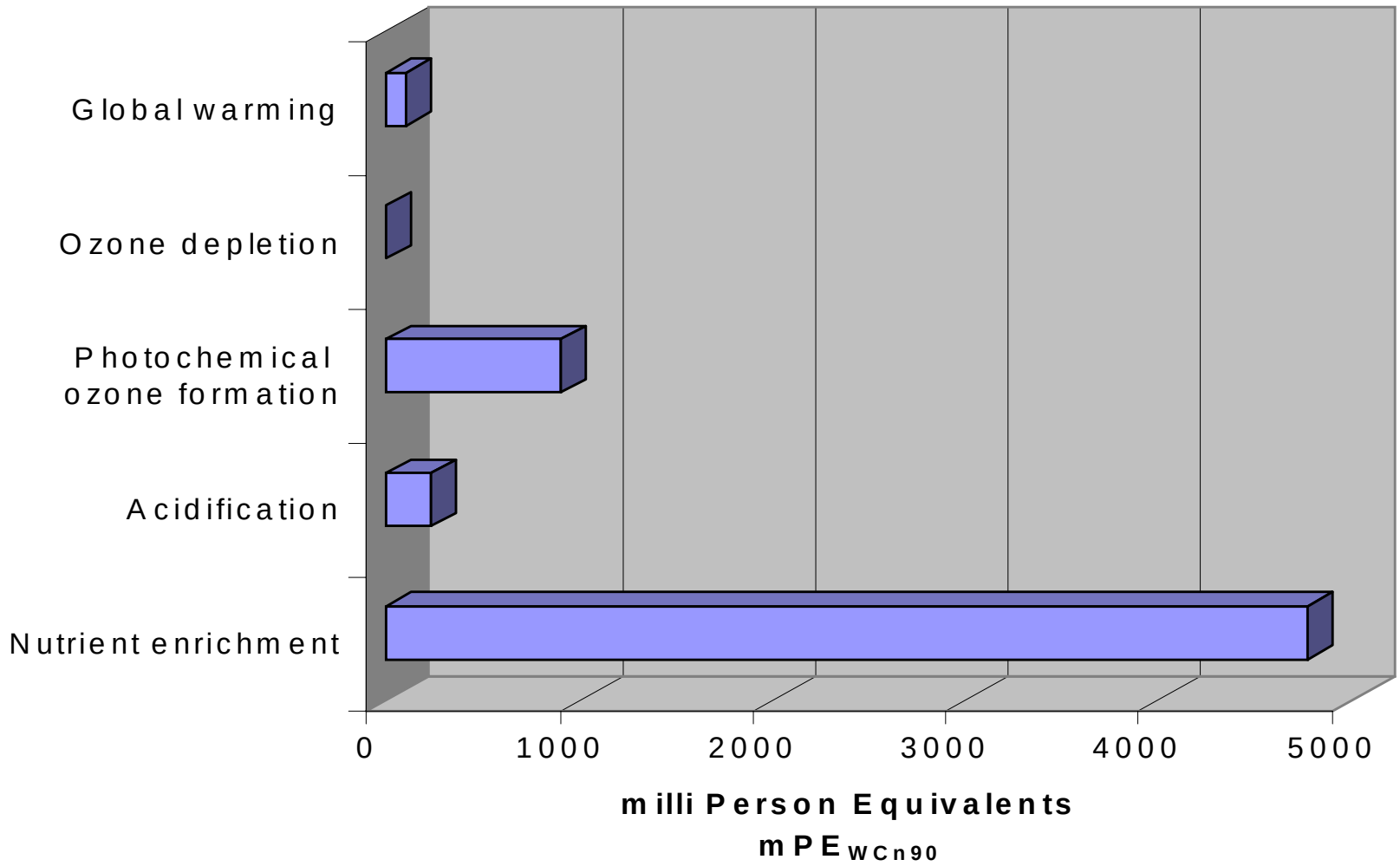
Materials & SW from Xiali production

Raw material	*kg per car*
Pyrite	113
Bauxite	67
Clay	32
Copper	10
Dolomite	14
Iron	861
Limestone	1,050
Sodium Chloride	30
Zinc	14

Solid waste	*kg per car*
Mineral	5,190
Mixed indu	573
Slagh & as	273
Inert	3

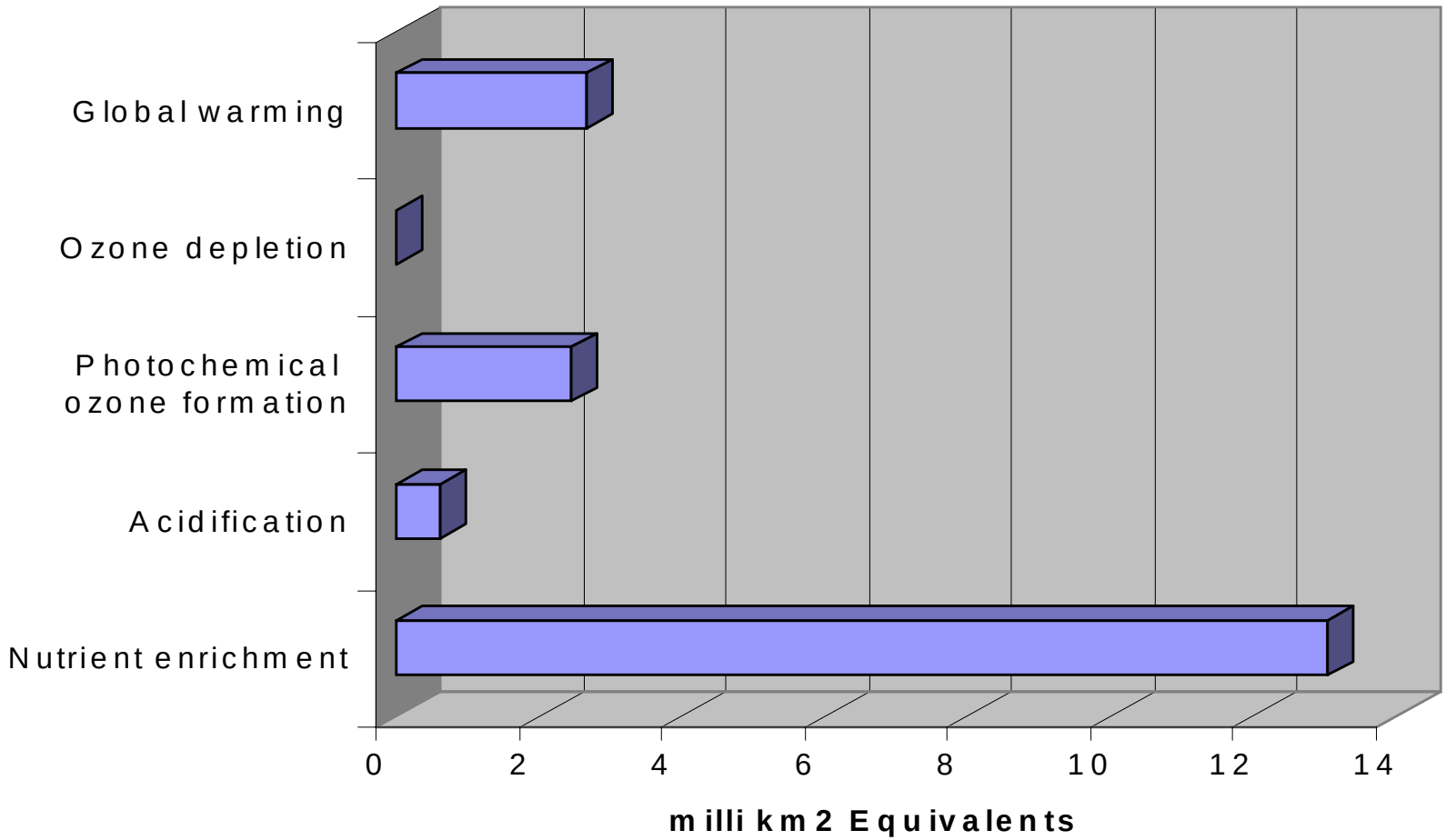
Normalized Environmental Impacts

How much does the Xiali contribute to environmental impacts compared with the contribution from 1 average person?

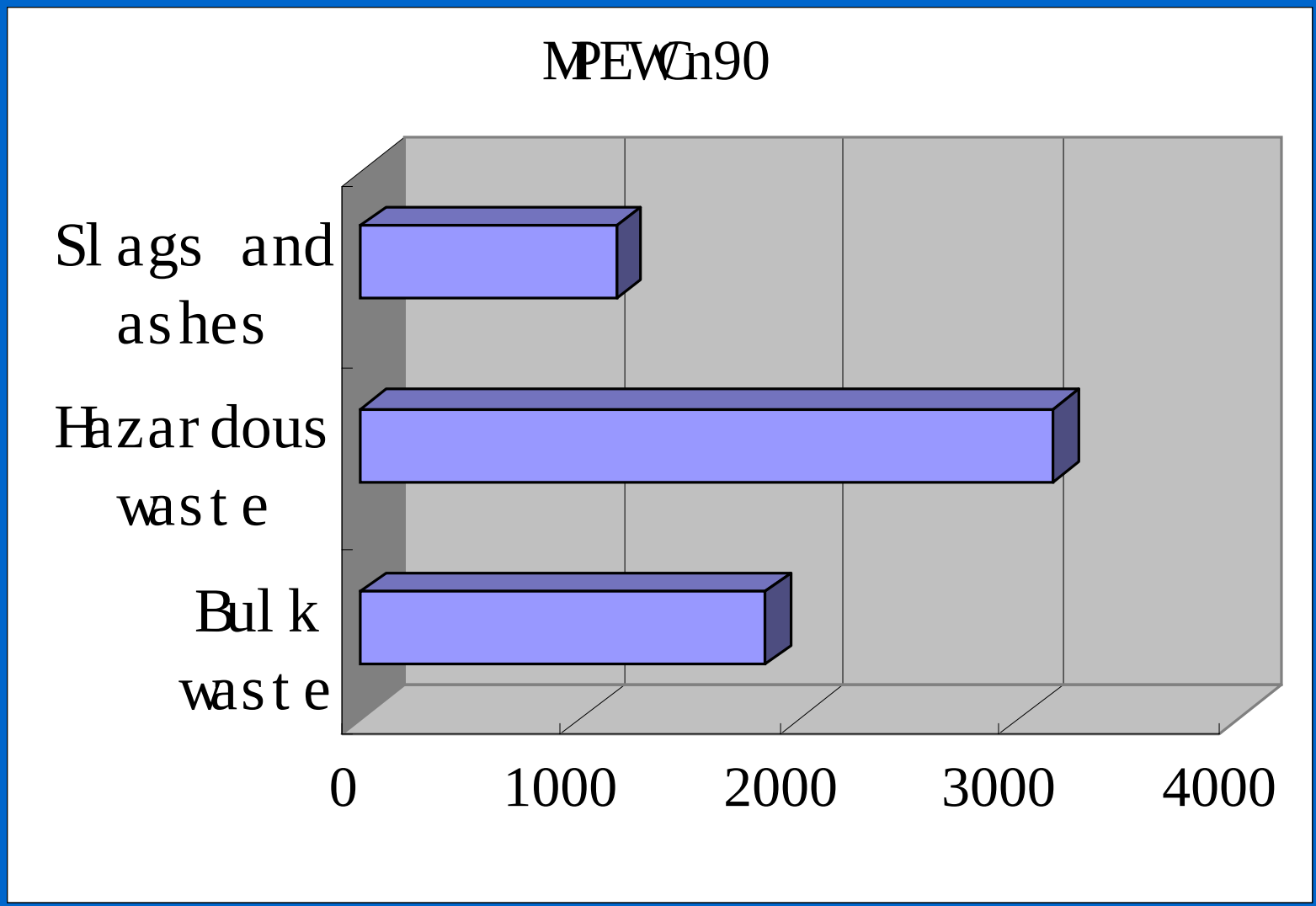


Normalized Environmental Impacts

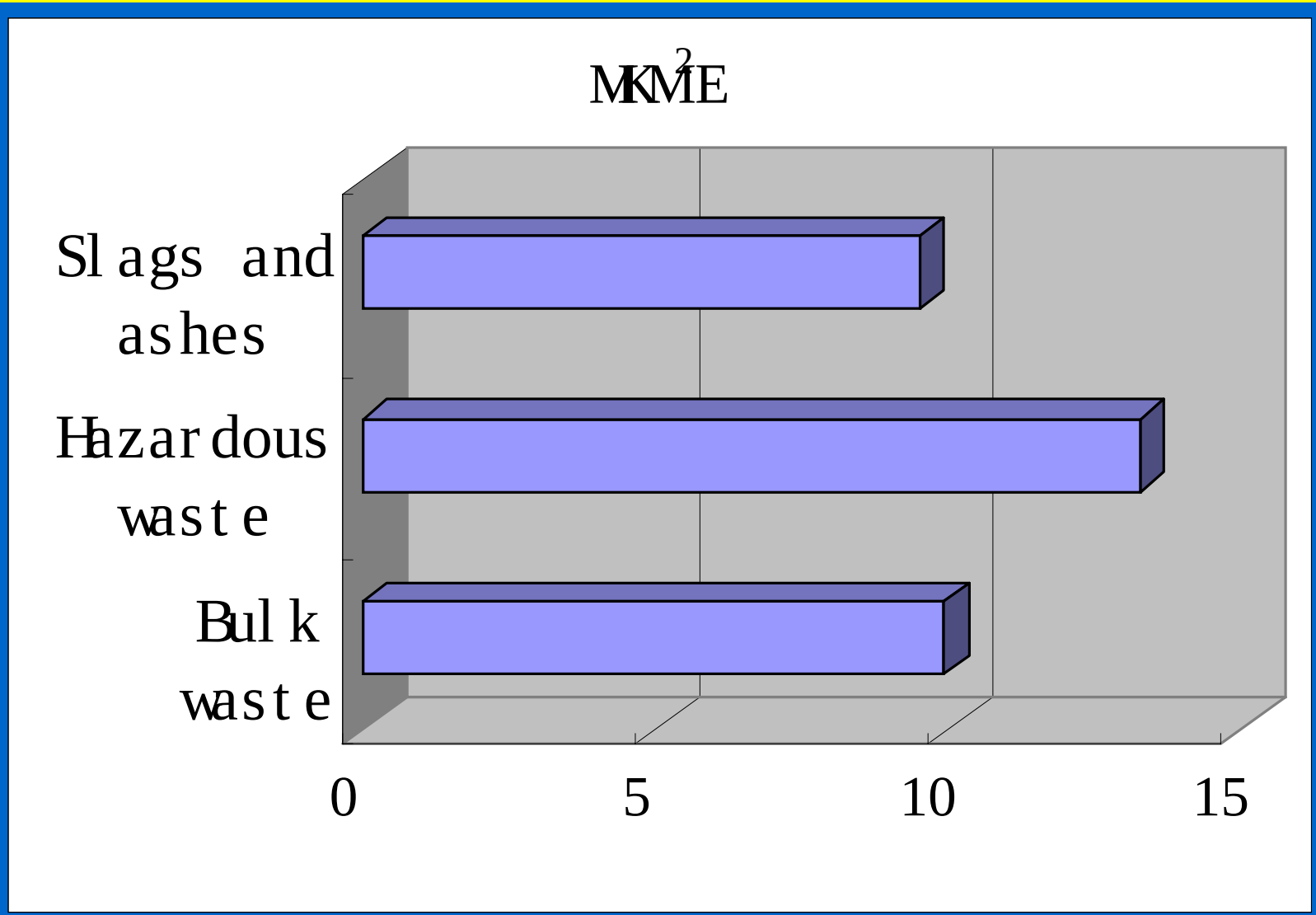
How much does the Xiali contribute to environmental impacts compared with the contribution from 1 square km?



Normalized EP from Wastes(I)



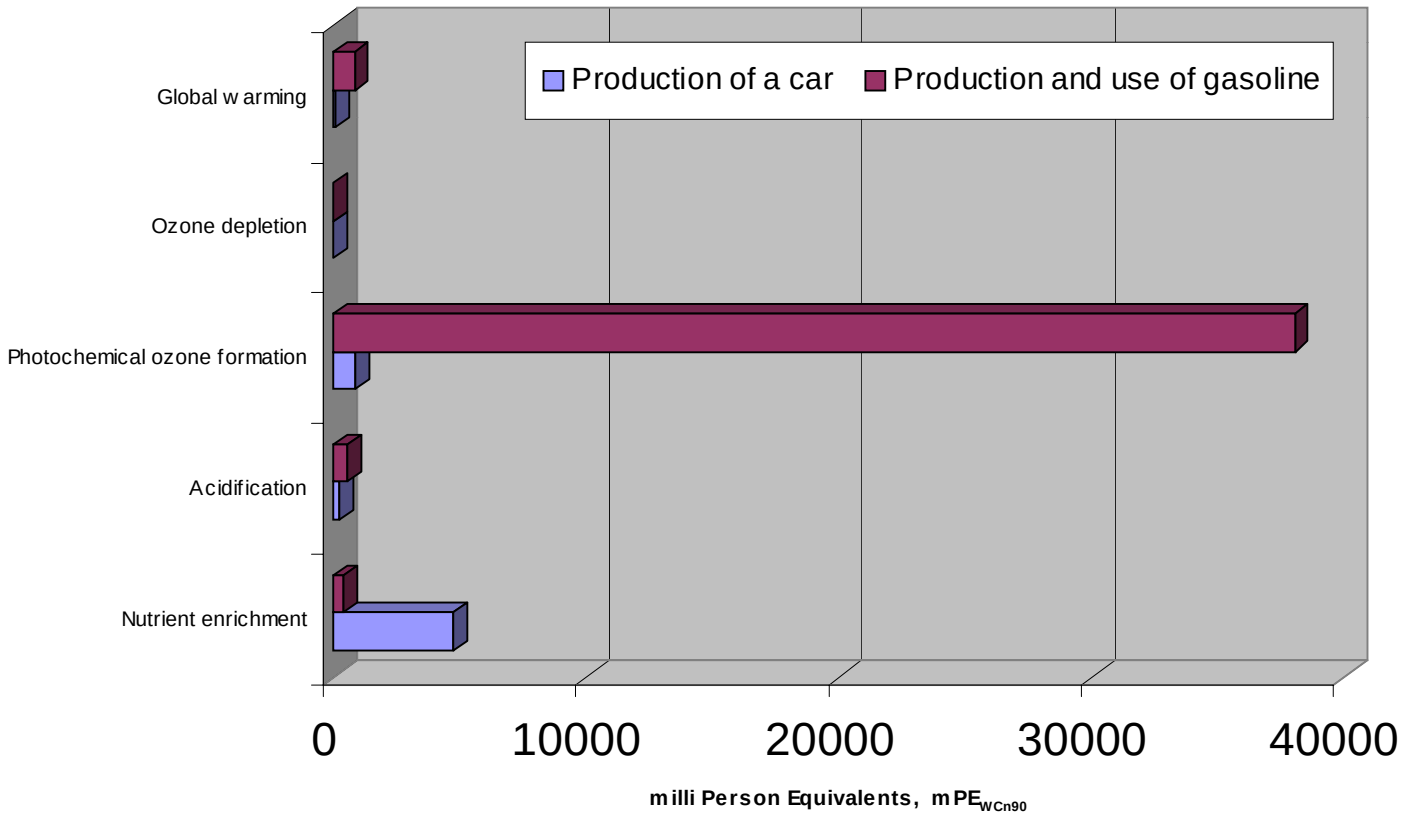
Normalized EP from Wastes(II)



Person-based normalization

Normalized Environmental Impacts

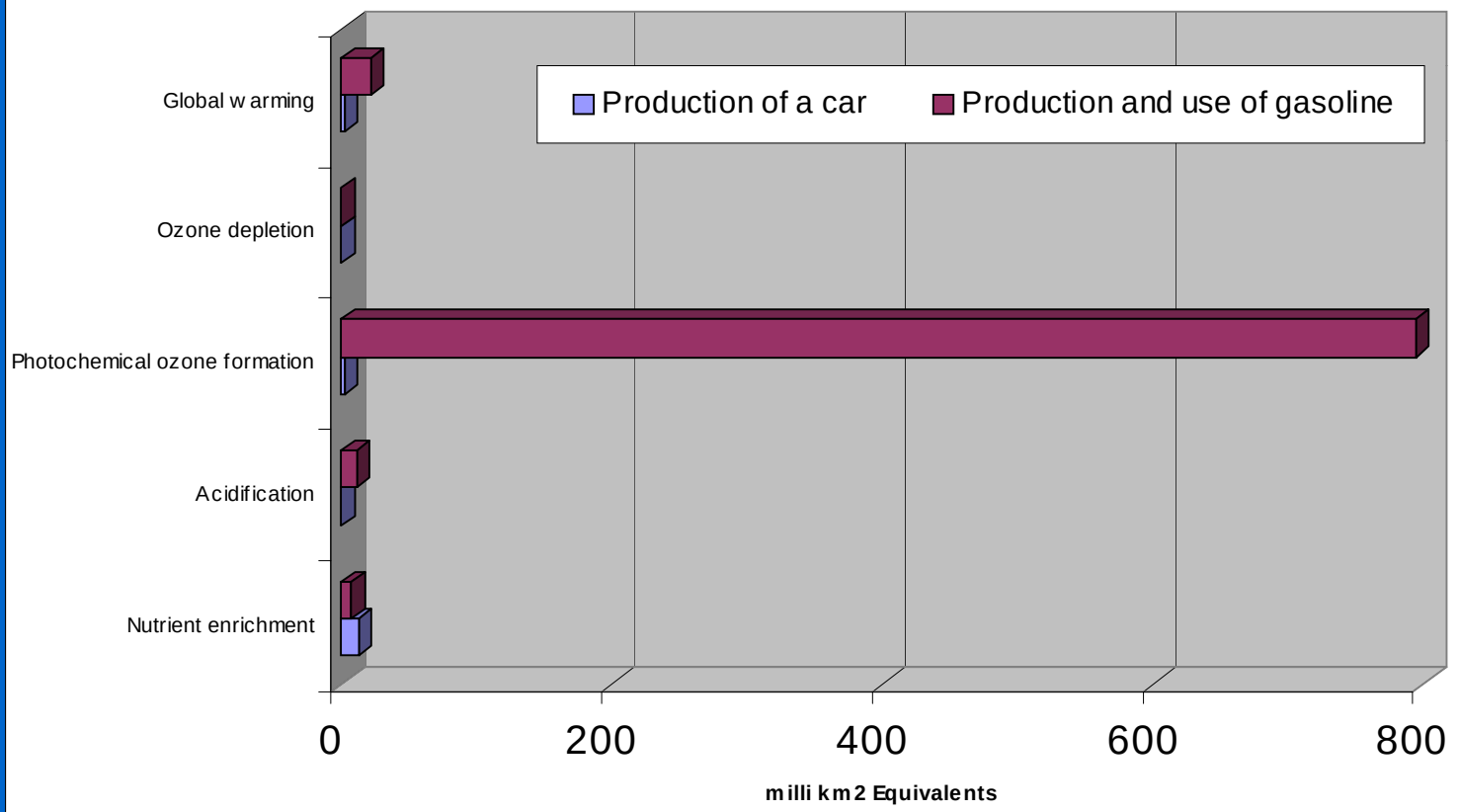
How much does the Xiali contribute to environmental impacts compared with the contribution from 1 average person ?



Produced in East & used in west

Normalized Environmental Impacts

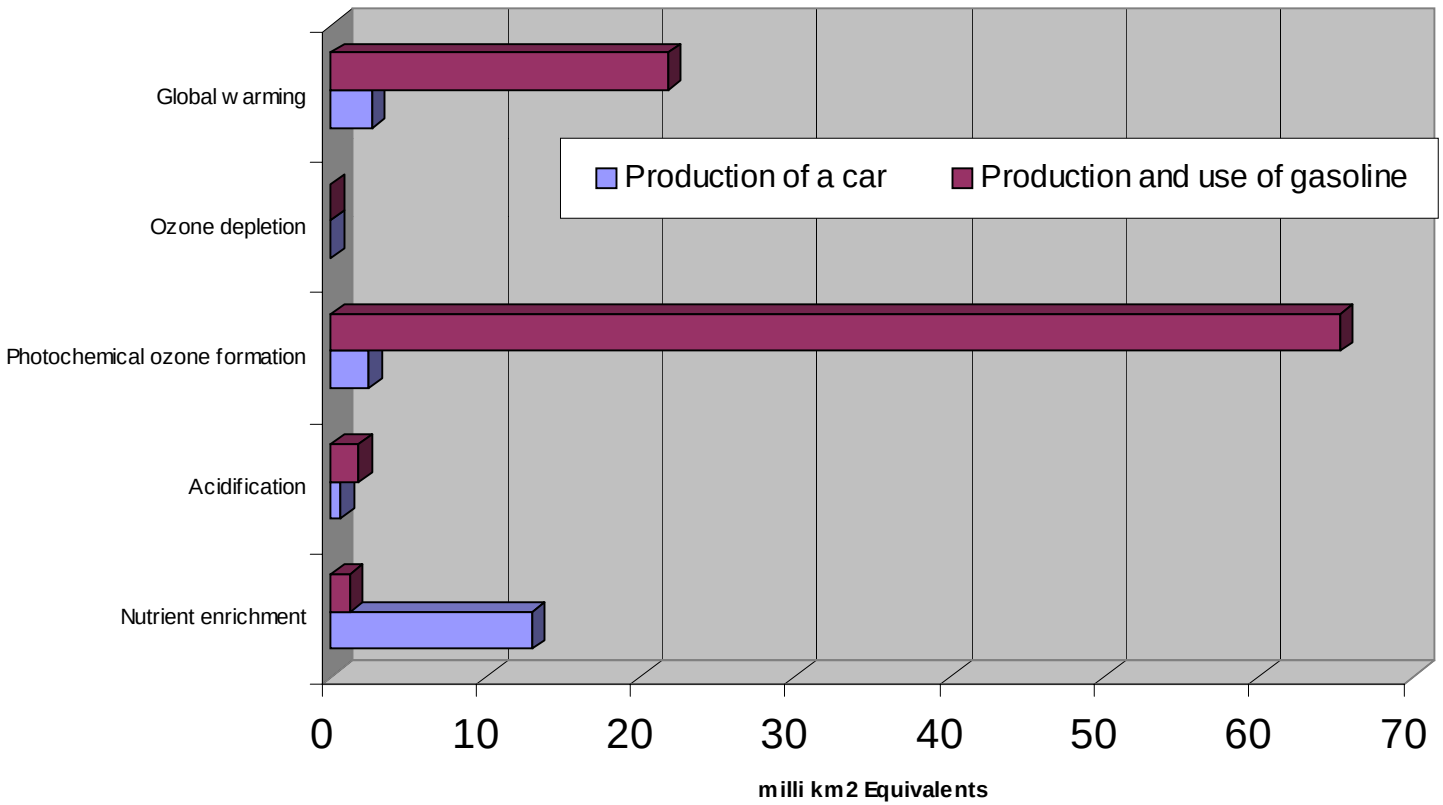
How much does the Xiali contribute to environmental impacts compared with the contribution from 1 square km ?



Produced & used in east region

Normalized Environmental Impacts

How much does the Xiali contribute to environmental impacts compared with the contribution from 1 square km ?



Comparison points

- There are different impact contribution patterns by two methods.
- The area-based method created a high GW potentials than that of person-based method.

Two questions to be answered

- Whether the normalization for resources consumption is also based on area equivalent ?
- Is the following weighting procedure also required to be done based on the site-policies?