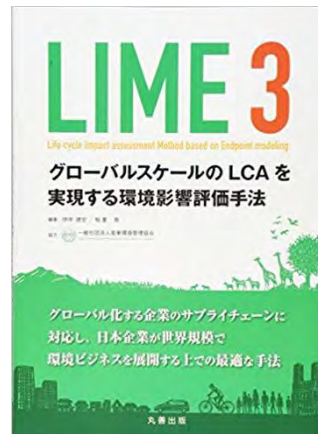
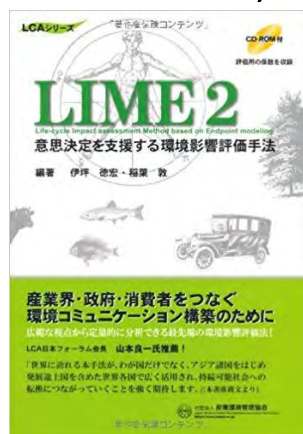


2019, September 9th 13:40 -14:10 -
@72th LCA Discussion Forum

Development of Normalization and Weighting Factors for G20 countries

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The International Journal of Life Cycle Assessment

ISSN: 0948-3349 (Print) 1614-7502 (Online)

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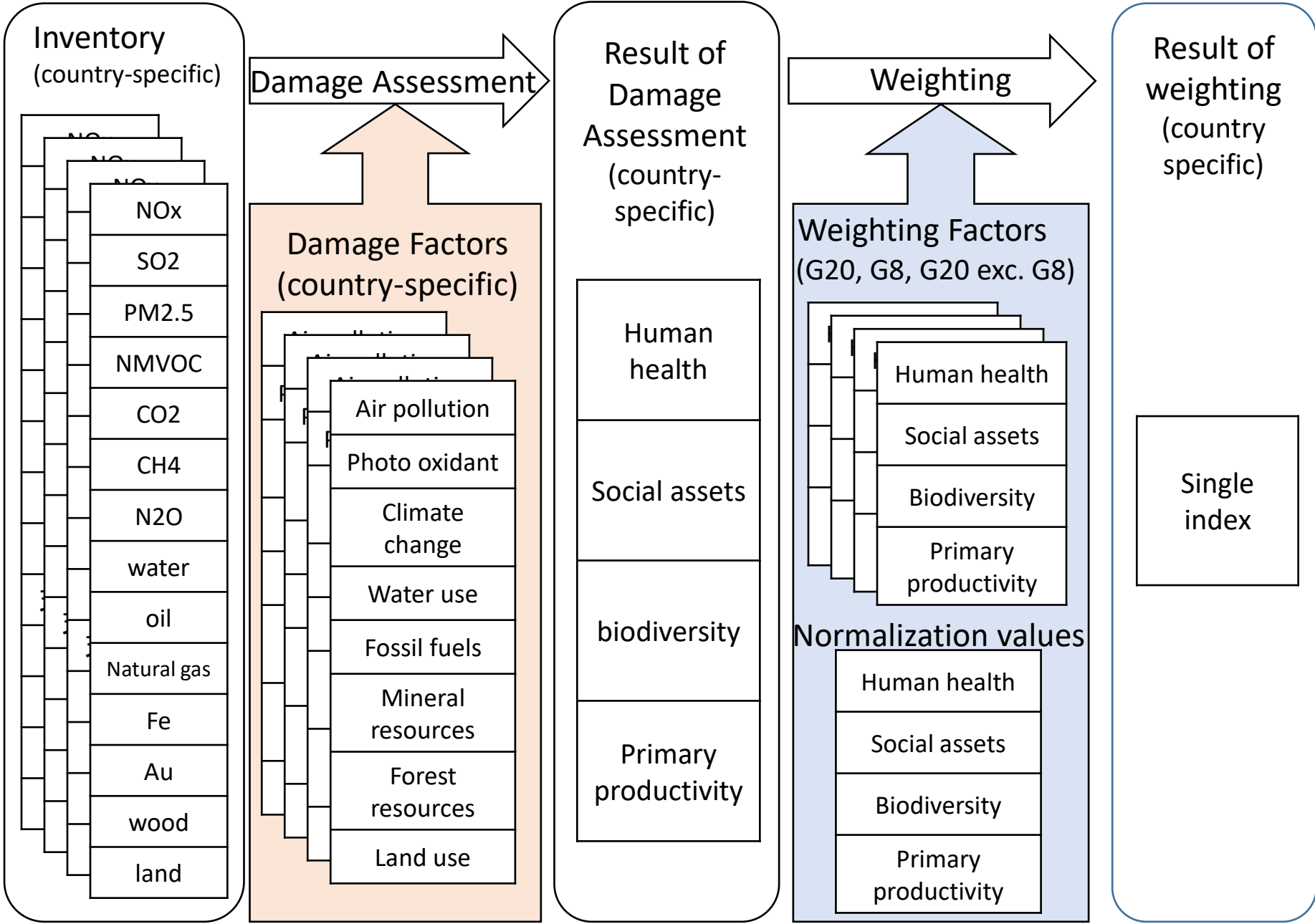
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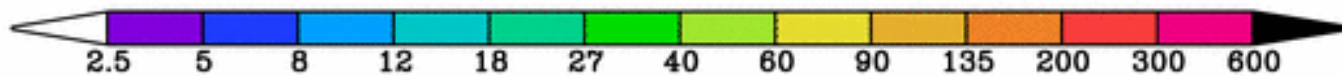
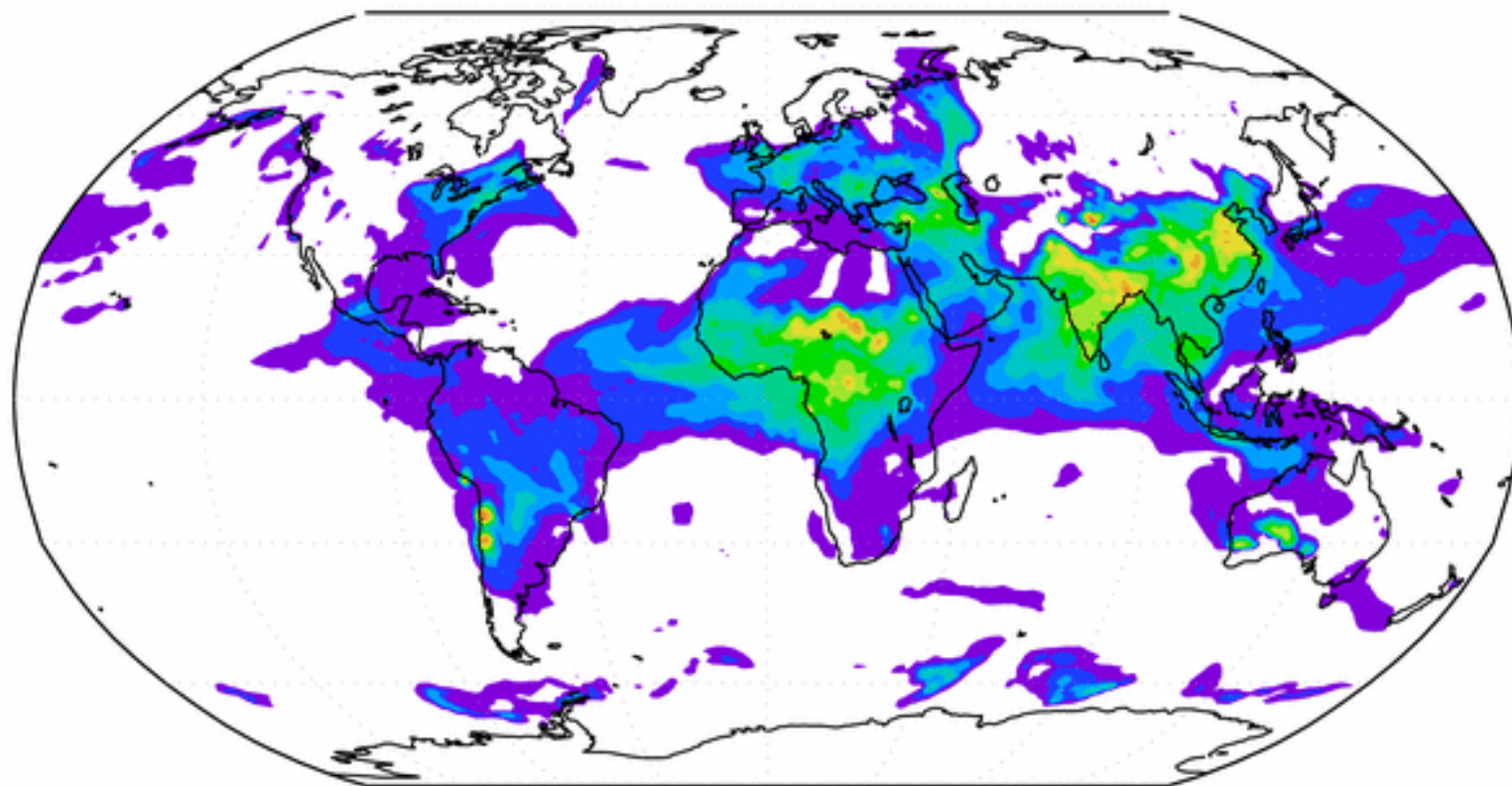
Special issue: Development of global scale LCIA method, LCIA in Japan, International Journal of Life Cycle Assessment

	title	Main author
1	Introduction to LIME3	Atsushi Inaba, Norihiro Itsubo
2	Development of SRES-based human health damage factors related to CO2 emissions	Long long Tang et al
3	Global Scale Human Health Damage Factor for Particulate matter	Long long Tang et al
4	Development of Damage Factor for Photochemical Ozone Creation	Long long Tang et al
5	Water Scarcity Damage Assessment Considering International Trade	Masaharu Motoshita et al
6	Ecosystem Damage Assessment of Land Use Using Biodiversity Loss	Kazuko Yamaguchi et al
7	Development of weighting factors for G20 countries – Explore the difference in environmental awareness between developed and emerging countries	Norihiro Itsubo et al
8	Development of weighting factors for G20 countries Part 2: Estimation of the amount of willingness to pay and annual damage cost in the world	Kayo Murakami et al.

LIME3 (a global scale environmental life cycle impact assessment method)



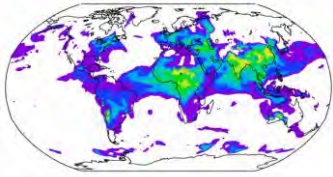
daily mean PM2.5[ug/m3] at surface : CTRL-run
[JAN 01, 2010]



リンク

Development of Damage Factors for Air pollution (SO₂, emitted at Middle East)

daily mean PM2.5[ug/m3] at surface - CTRL-run
[JAN 01, 2010]

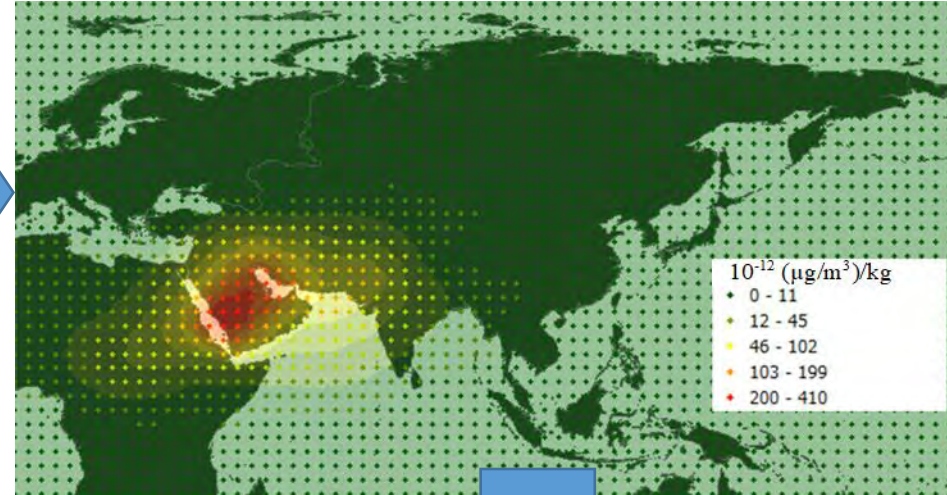


Background concentration

SO₂ 1kg emitted at Middle East



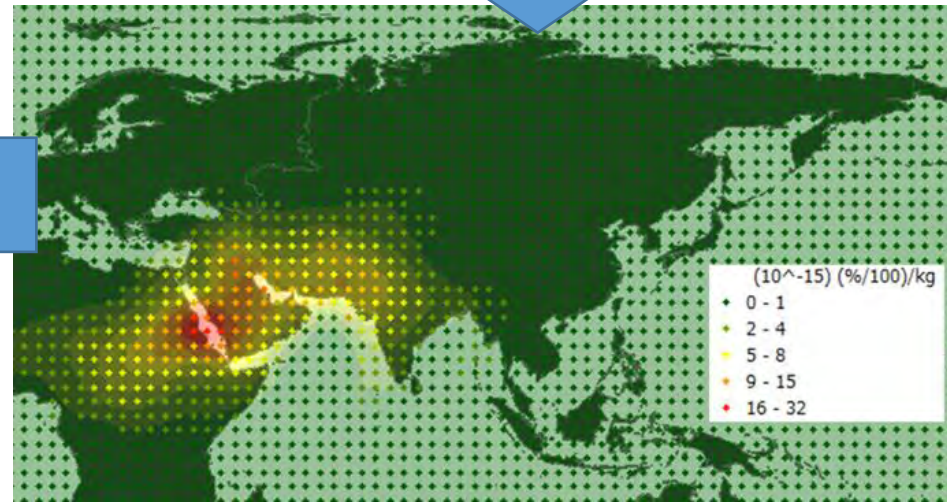
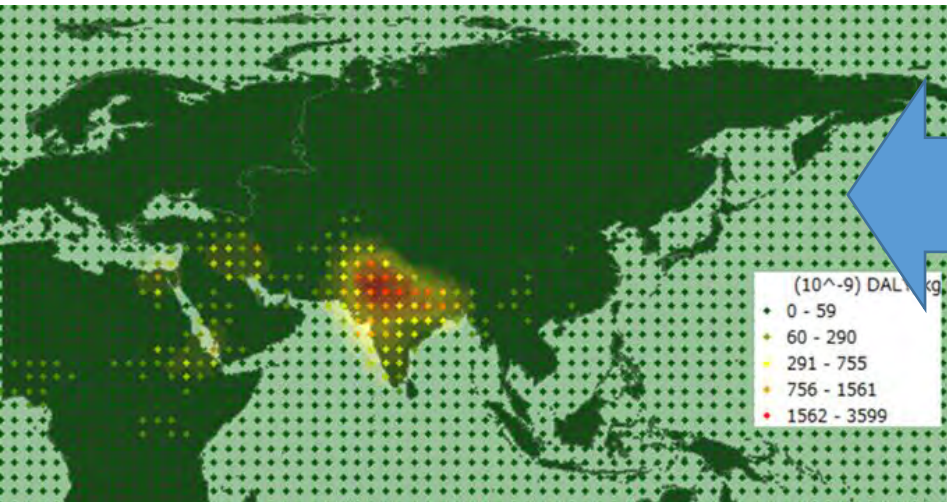
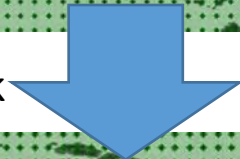
Change of Concentration of PM



1.09×10^{-4} Year/kgSO₂ (DF)

Increase of DALYs

Increase of health risk

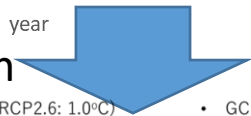
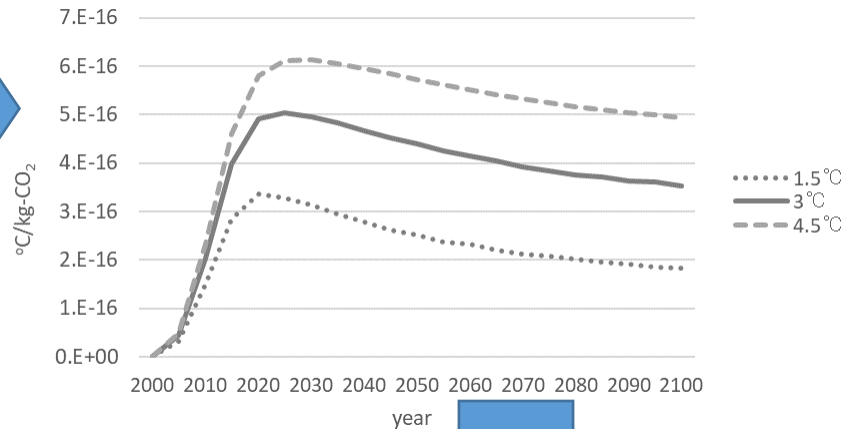


Procedure of damage factors for biodiversity caused by climate change

CO₂ 1kg emission



Temperature rise



Increase risk of extinction

- *A. angustifolia* (Gymnospermae)
- Occurrence data: red point
- Current potential habitat area: 1,756,090 (km²)
- AUC: 0.96
- GCM_1 (RCP2.6: 1.0°C)
- Future potential habitat area: 1,371,618 (km²)
- Ratio of area decrease: 22 (%)
- Extinction risk: 0.00017 (species/year)
- GCM_1 (RCP8.5: 2.3°C)
- Future potential habitat area: 1,242,471 (km²)
- Ratio of area decrease: 29 (%)
- Extinction risk: 0.00024 (species/year)



6.79×10^{-13} Species
(Damage Factor)

Integration of increase risk of extinction of species

List of Damage Factors

- Each country, impact category, endpoint
- Multiply with inventory data
- Enable to aggregate various inventory item

Excel spreadsheet showing a list of Damage Factors (DF) and their associated data. The spreadsheet is titled "係数リスト_20180719 - Excel".

The main table has columns for UN-code, country_name, 国名, JN_region, and various impact categories and endpoints. The impact categories are grouped into three main areas: Climate Change, Air pollution, and Photo oxidant. The endpoints are grouped into three main areas: Waste, Countries, and another set of endpoints.

Blue callout boxes highlight the following categories:

- Climate Change
- Air pollution
- Photo oxidant
- Waste
- Countries

UN-code	country_name	国名	JN_region	生物多様性	人間健康	人間健康	人間健康	人間健康	人間健康	人間健康	一次生産	社会資産	生物多様性	一次生産	社会資産	生物多様性
356	India	インド	Asia	6.79E-13	4.19E-07	1.58E-03	2.22E-04	3.34E-04	4.24E-05	2.91E-06	1.26E-02	1.65E-03	6.65E-14	1.74E-02	2.27E-03	9.14E-14
360	Indonesia	インドネシア	Asia	6.79E-13	4.19E-07	1.80E-04	4.43E-05	1.24E-05	7.03E-06	4.09E-07	2.67E-02	3.10E-03	9.20E-14	3.67E-02	4.27E-03	1.27E-13
364	Iran (Islamic Republic of)	イラン	Asia	6.79E-13	4.19E-07	3.98E-04	1.09E-04	4.12E-05	1.58E-05	1.37E-06	6.83E-03	1.18E-02	4.70E-16	9.40E-03	1.63E-02	6.46E-16
368	Iraq	イラク	Asia	6.79E-13	4.19E-07	3.98E-04	1.09E-04	4.12E-05	1.58E-05	1.37E-06	8.11E-03	1.10E-02	0.00E+00	1.12E-02	1.52E-02	0.00E+00
376	Israel	イスラエル	Asia	6.79E-13	4.19E-07	4.46E-04	1.23E-04	8.83E-05	3.51E-06	3.53E-06	9.10E-03	6.87E-02	0.00E+00	1.25E-02	9.44E-02	0.00E+00
392	Japan	日本	Asia	6.79E-13	4.19E-07	5.22E-04	6.88E-05	5.50E-05	4.47E-06	1.85E-06	1.42E-02	7.85E-02	5.35E-15	1.95E-02	1.08E-01	7.36E-15
400	Jordan	ヨルダン	Asia	6.79E-13	4.19E-07	3.98E-04	1.09E-04	4.12E-05	1.58E-05	1.37E-06	5.81E-03	8.24E-03	1.14E-15	7.09E-03	1.13E-02	1.56E-15

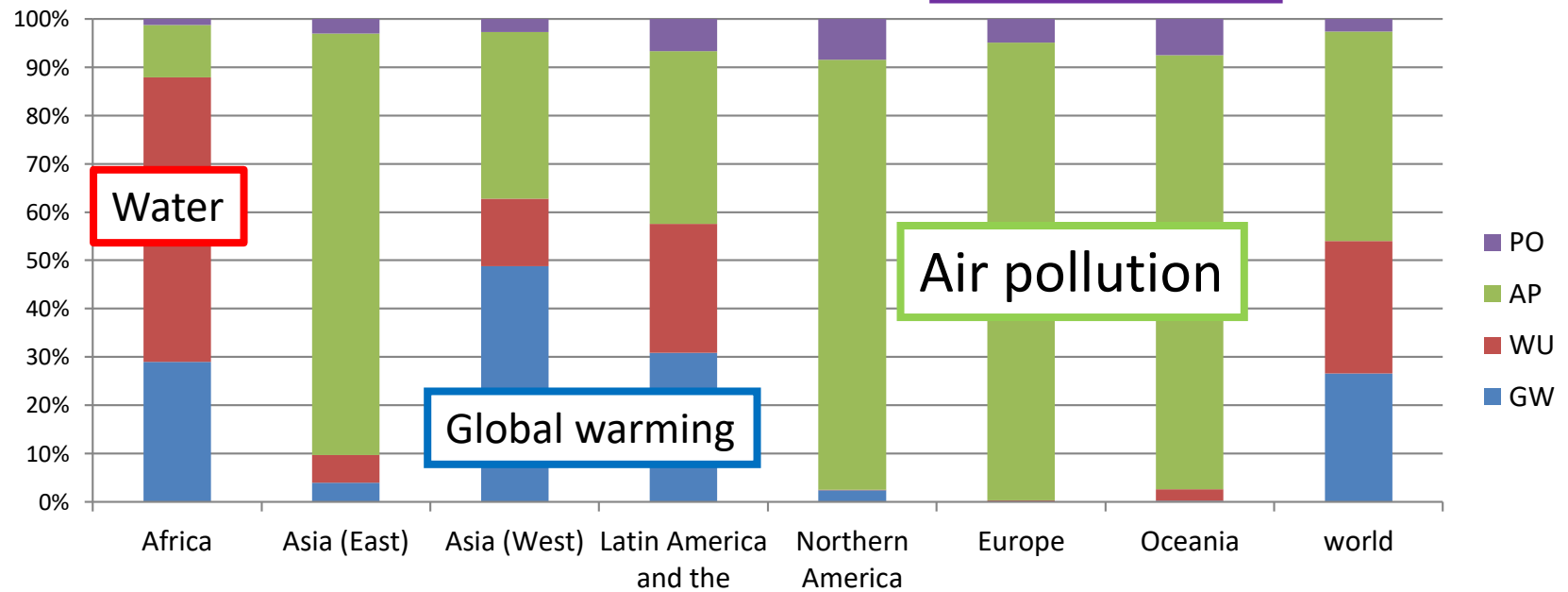
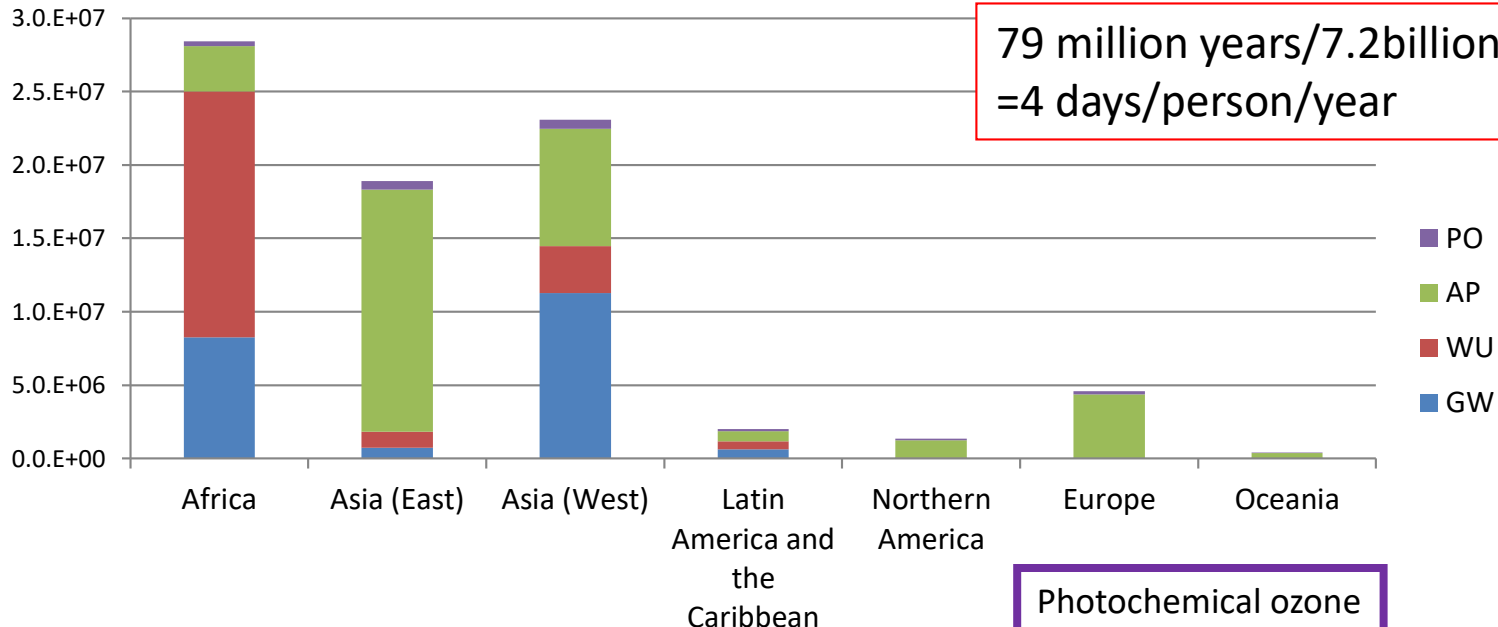
Normalization values (annual damage of each endpoint) and total economic impacts

	Human Health	Social Assets	Biodiversity	Primary Productivity
Impact category	DALY(years)	Million US\$	EINES(species)	Billion ton
Climate Change	2.1E+7	-4.6E+4	3.4E+1	-
Air pollution	3.4E+7	-	-	-
Photochemical ozone	1.9E+6	-	-	-
Water use	2.2E+7	-	-	-
Land use	-	-	5.2E+1	1.3E+1
Fossil fuel	-	2.9E+5	3.2E-1	1.5E-1
Mineral	-	1.6E+5	4.5E-2	2.6E+0
Forest resource	-	-	1.6E+1	4.6E+0
Total	7.9E+7	4.0E+5	1.0E+2	1.8E+1

Normalization value

Annual Environmental Impacts on Human Health

79 million years/7.2billion people/year
=4 days/person/year



Water

Photochemical ozone

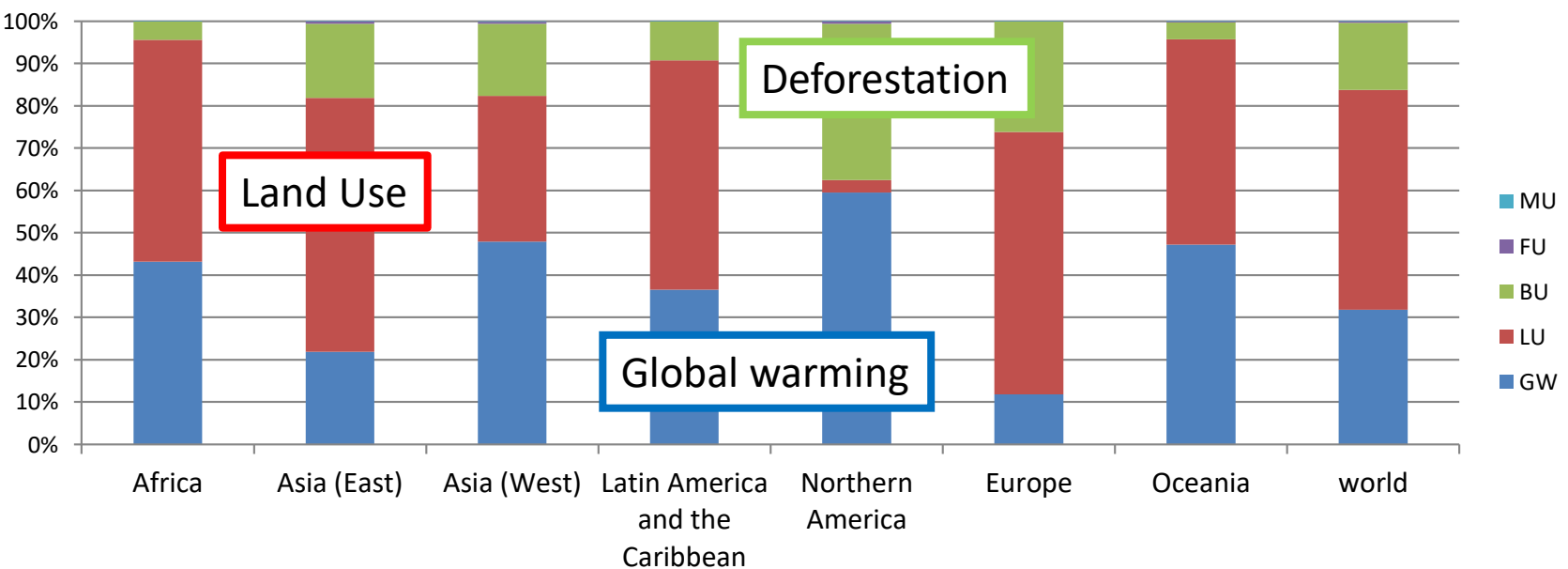
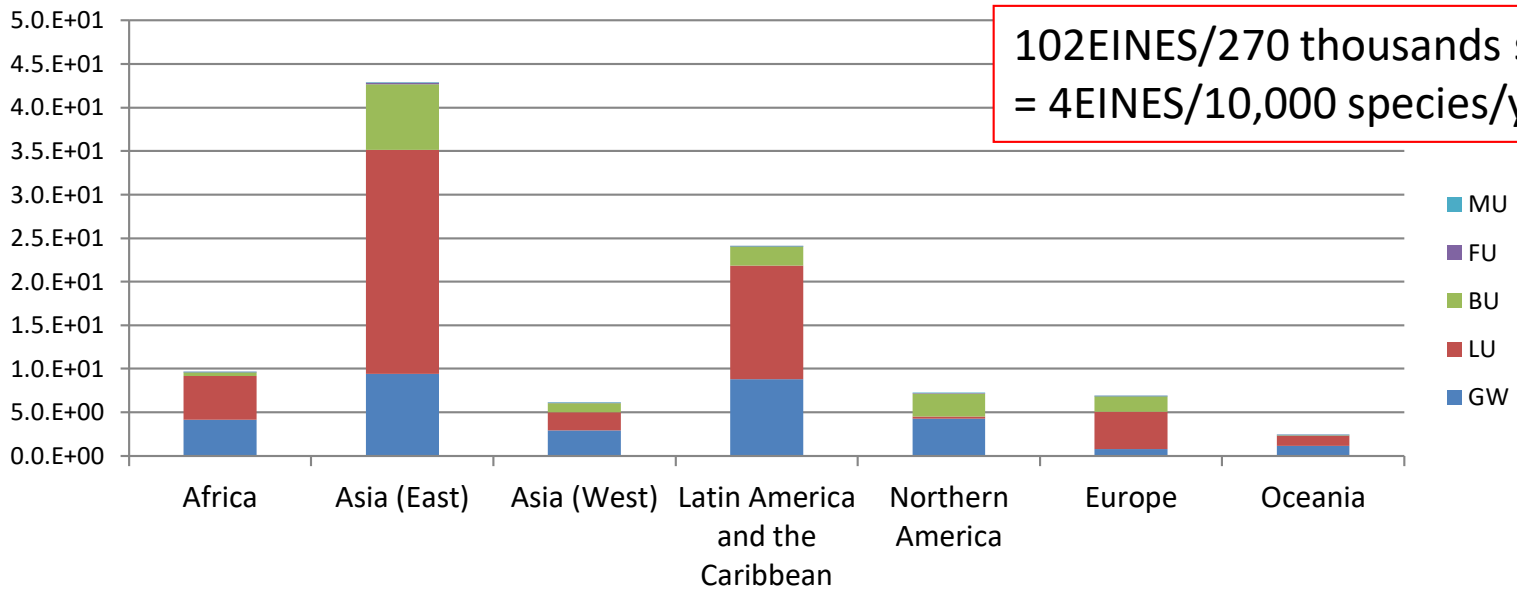
Air pollution

Global warming

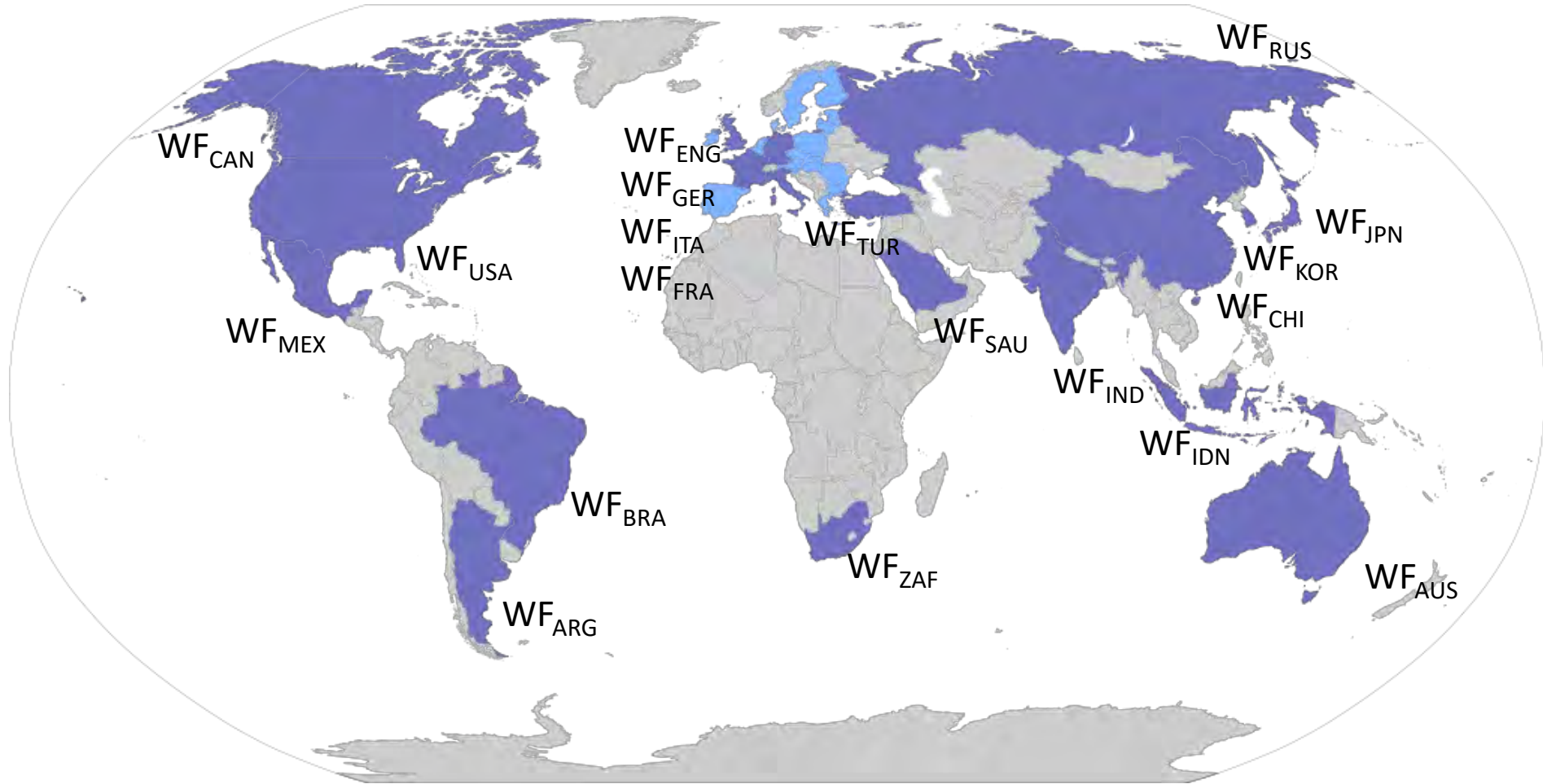
Normalization value

Annual Environmental Impacts on Biodiversity

102EINES/270 thousands species/year
= 4EINES/10,000 species/year



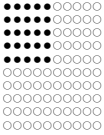
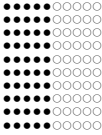
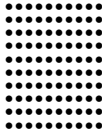
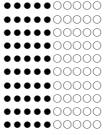
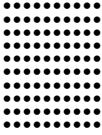
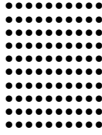
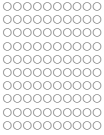
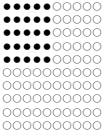
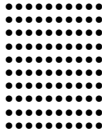
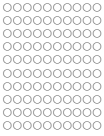
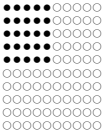
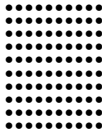
Development of weighting factors for G20 countries



Pretests and main survey

	Pretest (1st)	Pretest (2nd)	Pretest (3rd)	Main survey
Survey period	From Jan/2012 to Feb/2012	From Nov/2012 to Dec/2012	June 2013	From Aug 2013 to Sep 2013
Countries surveyed and procedure	5 countries (Japan, South Africa, Kenia, Viet Nam)	4 countries (USA (web), Japan (web, CLT), India (RW), China (CLT))	G20 countries G8 (web), G20 countries excluding G8 (CLT, RW, street intercept)	G20 countries G8 (web), G20 countries excluding G8 (CLT, RW, street intercept)
The number of samples	50 (CLT, RW)	50 (CLT, RW)、100 (Web)	50 (web, CLT, RW, street intercept)	500 – 600 (web), 200 (CLT, RW)

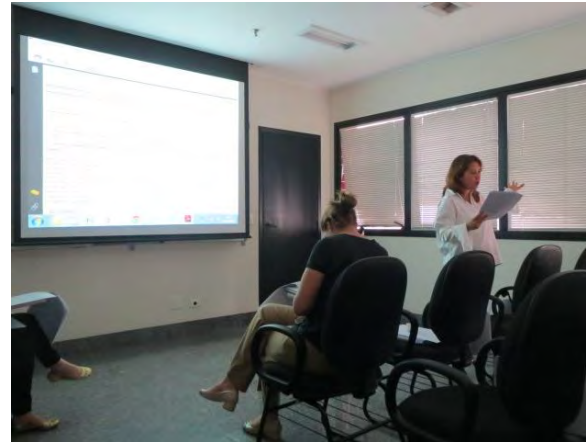
Example of profile

		Plan A	Plan B	No action (Plan C)
L O S S	Loss of health per person Human health	 Lose 1 day a year	 Lose 2 days a year	 Lose 4 days a year
	Loss of natural resources per person Social assets	 Lose 30US\$ a year	 Lose 60US\$ a year	 Lose 60US\$ a year
	Loss of species Biodiversity	 No species extinct	 25 species extinct a year	 100 species extinct a year
	Loss of forests Primary production	 No loss of forests	 5 billion tons a year	 20 billion tons a year
	T A X	Addnl. TAX (yearly per household)	Additional 500US\$ yearly	Additional 300US\$ yearly

Russia



Brazil



Saudi arabia



Turkey



South Africa



Mexico



China



Main survey

Turkey



India



Saudi Arabia



Brazil



China



Argentina



Russia



Mexico

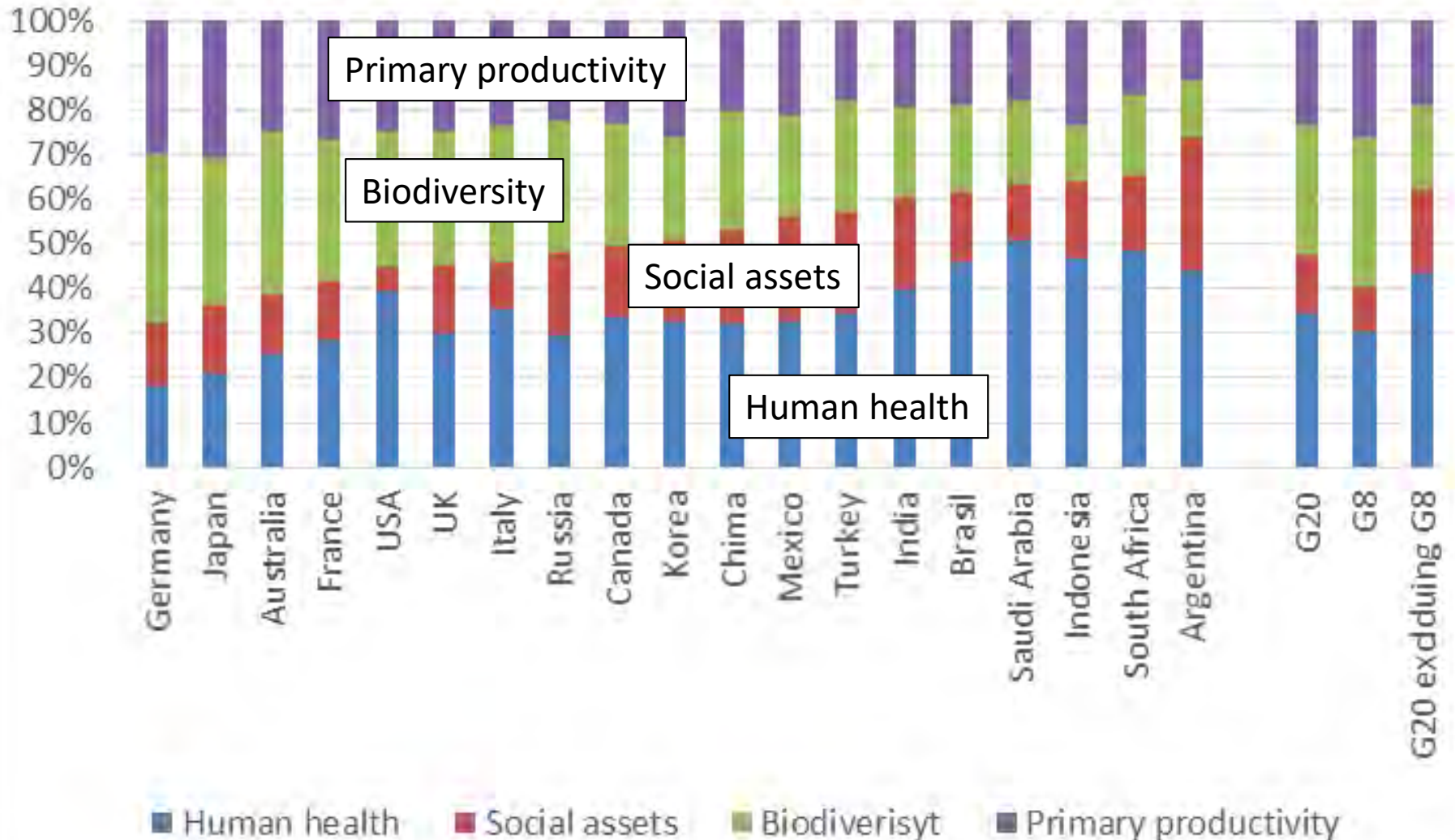


South Africa



Results

Weighting factors for country specific, G20, G8 and emerging countries



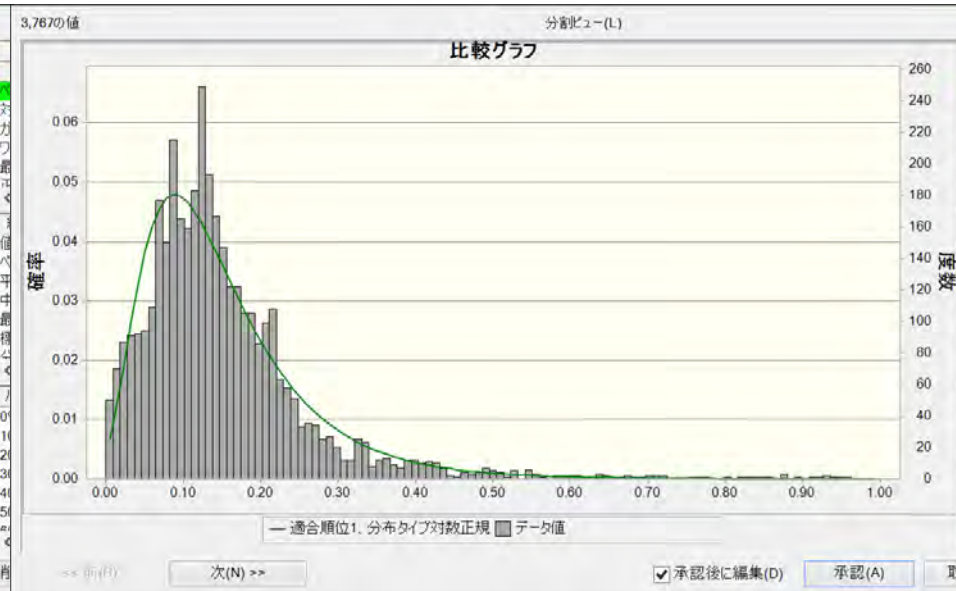
Results

Frequency distribution of weighting factors (G8 countries)

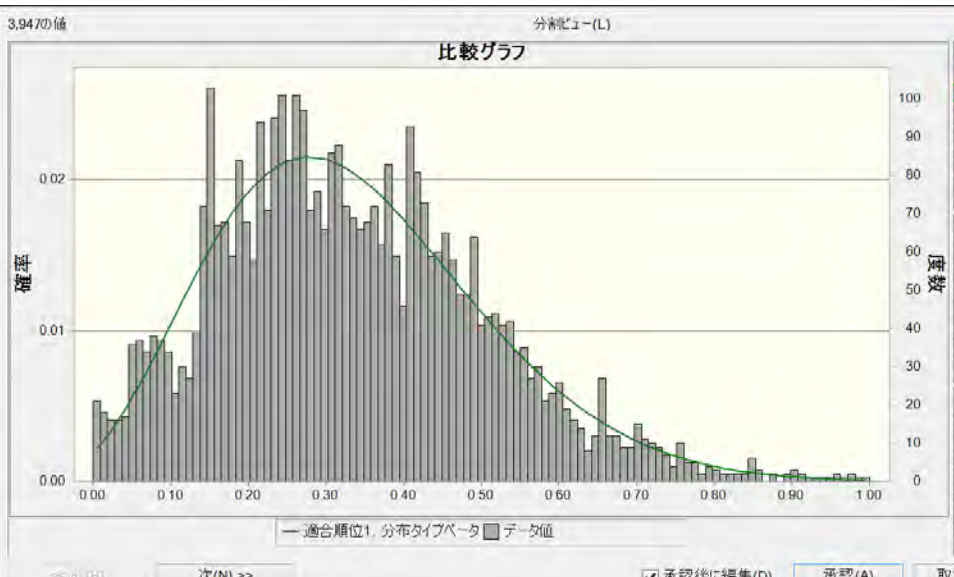
Human health



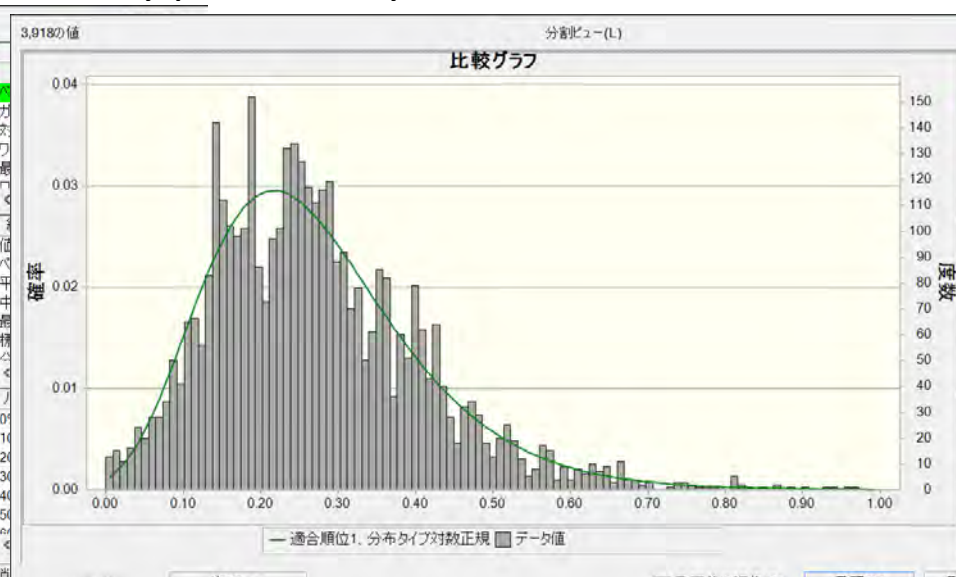
Social assets



Biodiversity



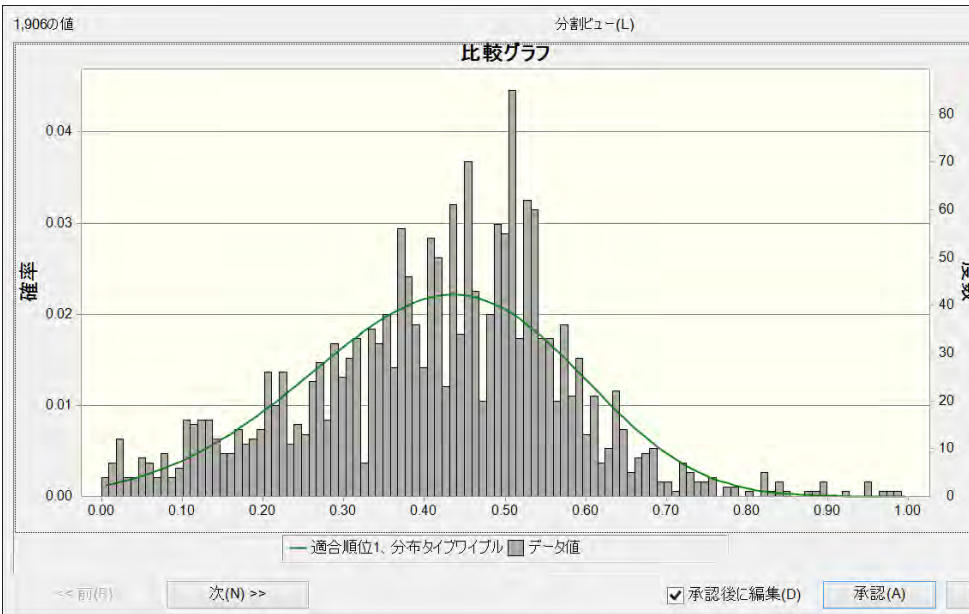
Primary productivity



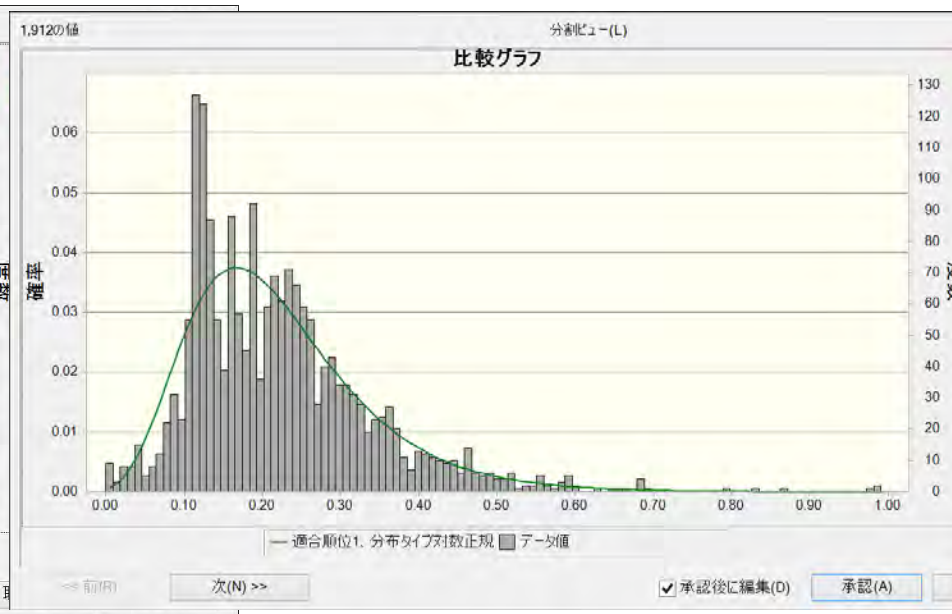
Results

Frequency distribution of weighting factors (Emerging countries)

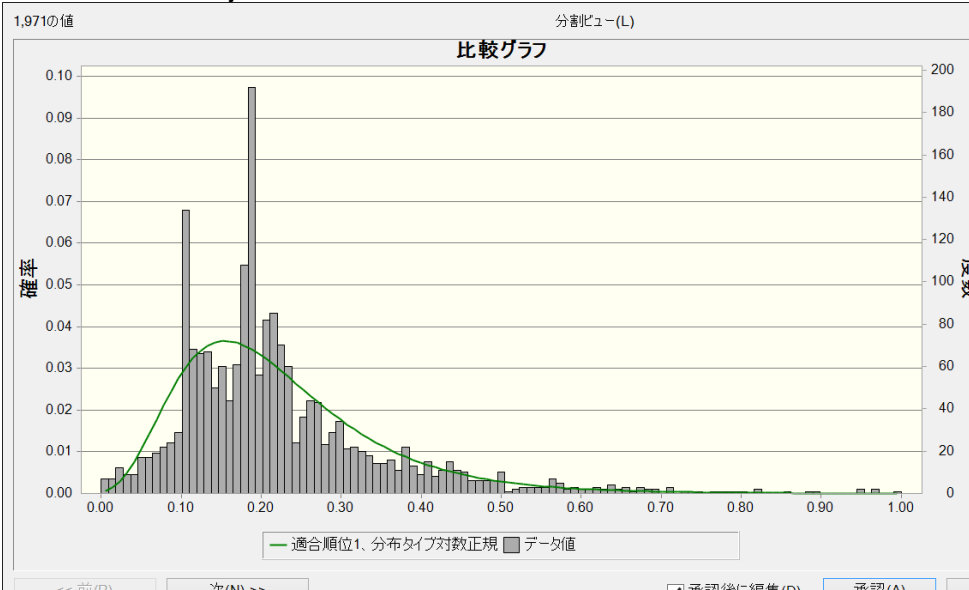
Human health



Social assets



Biodiversity

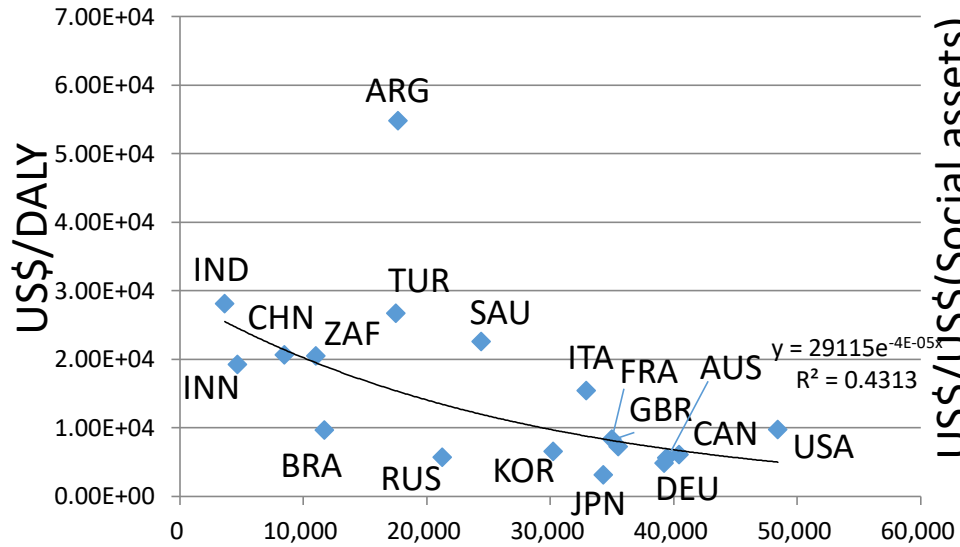


Primary productivity

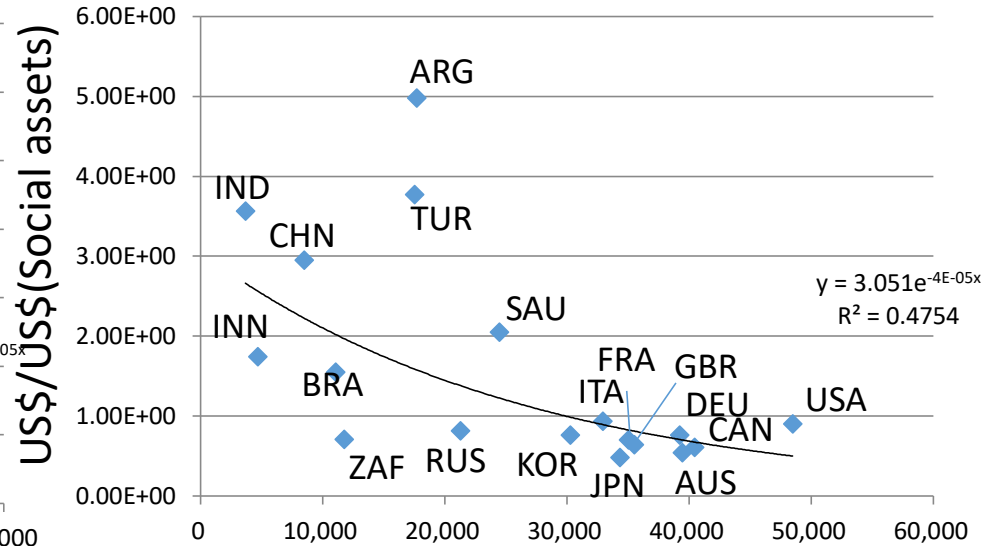


WTPs in G20 countries

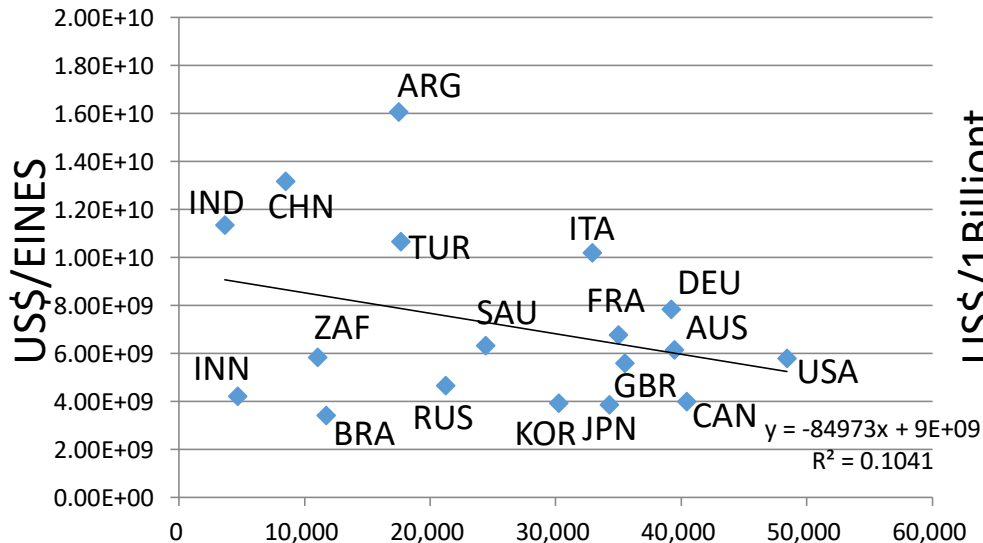
Human health



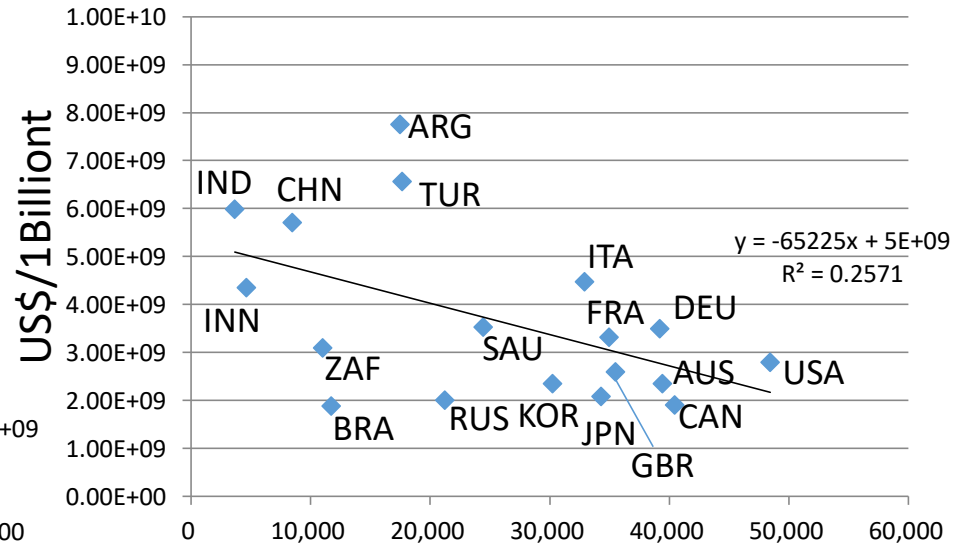
Social assets



Biodiversity



Primary productivity



List of Integration Factors

- Each country, impact category, endpoint
- Multiply with inventory data
- Enable to aggregate various inventory item

Excel spreadsheet titled "係数リスト_20180719 - Excel" showing a table of integration factors. The table is organized into columns for impact categories and endpoints. Blue arrows point from labels to specific cells in the table.

UN-code	country_name	国名	UN_region	地球温暖化			大気汚染			光化学オキシダント			Waste			
				CO2 (B2)	PM2.5	O3	PM2.5	PM2.5	PM2.5	PM2.5	PM2.5	PM2.5	PM2.5	PM2.5	PM2.5	PM2.5
392	Japan	日本	Asia	7.47E-03	9.63E-03	1.20E+01	1.58E+00	1.27E+00	1.03E-01	4.25E-02	7.92E-04	1.96E-01	5.88E-05	1.09E-03	2.70E-01	8.09E-05
400	Jordan	ヨルダン	Asia	7.47E-03	9.63E-03	9.15E+00	2.52E+00	9.48E-01	3.64E-01	3.15E-02	3.25E-04	2.06E-02	1.25E-05	4.48E-04	2.83E-02	1.72E-05
398	Kazakhstan	カザフスタン	Asia	7.47E-03	9.63E-03	4.21E+00	1.85E+00	1.03E+00	1.24E-01	4.10E-02	5.42E-04	4.15E-02	2.68E-05	7.45E-04	5.70E-02	3.69E-05
414	Kuwait	クウェート	Asia	7.47E-03	9.63E-03	9.15E+00	2.52E+00	9.48E-01	3.64E-01	3.15E-02	0.00E+00	4.12E-01	0.00E+00	0.00E+00	5.66E-01	0.00E+00
417	Kyrgyzstan	キルギス	Asia	7.47E-03	9.63E-03	4.21E+00	1.85E+00	1.03E+00	1.24E-01	4.10E-02	5.48E-04	2.49E-03	7.91E-05	7.53E-04	3.42E-03	1.09E-04
418	Lao People's Democ	ラオス	Asia	7.47E-03	9.63E-03	2.51E+01	4.33E+00	4.64E+00	3.22E-01	1.28E-01	1.29E-03	3.91E-03	1.25E-04	1.77E-03	5.38E-03	1.72E-04
422	Lebanon	レバノン	Asia	7.47E-03	9.63E-03	9.15E+00	2.52E+00	9.48E-01	3.64E-01	3.15E-02	5.77E-04	3.07E-02	6.53E-06	7.93E-04	4.22E-02	8.97E-06

Labels and arrows pointing to specific cells:

- Climate Change** points to the "地球温暖化" header.
- Air pollution** points to the "大気汚染" header.
- Photo oxidant** points to the "光化学オキシダント" header.
- Waste** points to the "Waste" header.
- Countries** points to the "country_name" column.

Normalization values (annual damage of each endpoint) and total economic impacts

	Human Health	Social Assets	Biodiversity	Primary Productivity
Impact category	DALY(years)	Million US\$	EINES(species)	Billion ton
Climate Change	2.1E+7	-4.6E+4	3.4E+1	-
Air pollution	3.4E+7	-	-	-
Photochemical ozone	1.9E+6	-	-	-
Water use	2.2E+7	-	-	-
Land use	-	-	5.2E+1	1.3E+1
Fossil fuel	-	2.9E+5	3.2E-1	1.5E-1
Mineral	-	1.6E+5	4.5E-2	2.6E+0
Forest resource	-	-	1.6E+1	4.6E+0
Total	7.9E+7	4.0E+5	1.0E+2	1.8E+1
Economic values (US\$)	7.67E+11	2.95E+11	6.41E+11	5.22E+11
	Total 2.23E+12			
Per capita (US\$)	1.12E+2	4.29E+1	9.32E+1	7.58E+1
	Total 3.23E+2			

Assessed Products and Hotspot of Environmental Impacts

Company	Assessed Products	Impact categories								
		CC	AP	PO	WU	MR	FF	BR	LU	WA
Taiheiyo cement	Cement (8 countries inc. Japan, India, US)	◎	◎	○		○	○			◎
Sanmesse	Handout (Japan, Indonesia)	○	○		○	○	◎	◎		
Shiseido	Soap for hand washing	○	○	○	◎	○	○	○	◎	○
Nissan	Automobile	◎	○	○	○	◎	◎			○
Sekisui chemicals	Plastic products	◎	◎	○	○	○	◎	○	○	○

◎ : Hotspot, ○ Assessed Impact category, Blank : Out of scope

CC: Climate Change, AP: Air Pollution, PO: Photochemical Oxidant, WU: Water use, MR: Mineral resource use, FF: Fossil fuel use, BR: Biotic Resources use, LU: Land Use, WA: Waste

Summary

- Development of damage factors and normalization values of LIME3 have been introduced. Normalization values can be used as a reference data for weighting across the endpoints adopted in LIME3.
- Procedure and results of weighting factors have also been introduced. According to the result, emerging countries have a higher priority on human society, developed countries have higher weights on ecosystem.
- The variation of individual weights across endpoints exists, but it was possible to obtain the representative values of weighting factors in society.
- Integration factors obtained from damage factors and weighting factors can be applied to LCIA case studies. Case study for electricity in G20 showed that there is a special difference of their results.