Environmental impacts of electricity generation at global, regional and national scales in 1980 – 2011: What can we learn for future energy planning?

Electronic Supporting Information ESI-1

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This document includes:

- Supplementary Methods
- Supplementary Results and Discussion (complementary part to ESI-2)
- Supplementary References

Supplementary Methods

Electricity generation data

Historical data were collected from the Data Shift project (2014),[1] which compiles original data from the US Energy Information Agency (EIA) and the World Bank database. Data were retrieved for 199 countries and territories. Territories mainly refer to small islands, which administratively are integral part of already-mapped countries, but because of the different geographic locations are kept separated in the inventory (e.g. Guadeloupe, Martinique, etc.). The number of territories account for ca. 10. In the following, the term "country" is used as representative for the 199 countries and territories.

The distributions of the generated electricity from coal, gas and oil sources was retrieved from the World Bank database[2] for 21 out of 41 countries in Central and South America (ca. 89% of produced thermal electricity in 2009), 27 out of 52 countries in Africa (ca. 98% of produced thermal electricity in 2009), 21 out of 39 countries in Asia and Oceania (ca. 100%), 14 out of 14 countries in Eurasia (100%), 31 out of 34 countries in Europe (ca. 100%), 13 out of 13 countries in Middle East (100%), 3 out of 6 countries in North America (ca. 100%). Original data thus cover ca. 99.6% of worldwide generated electricity from fossils (2009 taken as reference).

A number of extrapolations and assumptions were however necessary to fill in gaps with regard to fossil-based electricity generation:

- Distributions of coal-, gas- and oil-based electricity for unreported African countries were taken as either the average of sub-Sahara developing countries or as the average of the Middle East/North African developing countries (based on geographical location of the unreported countries). Exceptions include Swaziland and Lesotho, which were taken similar to the South African fossil mixes.
- Distributions in coal, gas and oil sources in Laos, Bhutan, Afghanistan and Macao were taken similar to South Asian averages, whereas small islands in Asia and Oceania were extrapolated from East Asia and Pacific averages (all incomes - developing and developed countries mixed).
- Gaps in Central and South America (mainly small islands) for coal, oil and gas apportionments were filled in using Latin America and Caribbean averages (all incomes - developing and developed countries mixed).
- The apportionments of coal, oil and gas in the thermal electricity mix for Russia in the period 1980-1989 were taken identical to the fossil mix distribution in 1990.
- In Europe, the distributions of coal, oil and gas for Montenegro were assumed the same as for Serbia, for Gibraltar as for Spain, and Faroe islands as Iceland (based on geographical considerations).
- The apportionments of coal, oil and gas in the thermal electricity mix for Saint-Pierre-et-Miquelon, Greenland and Bermuda were taken as the corresponding averages for North America.

For the year 2011, a number of data gaps (specific to energy sources) were present in the WDB and EIA reports for several countries. These gaps were filled in using linear extrapolations from the 2009-2010 trends. These two years are posterior to the crisis of 2007-2008, which can be observed by a distinct level-off (see Fig. SM1 below), and are therefore believed to be consistent with the year 2011. The difference between the total generated electricity before and after filling in the gaps amounts to 4.1%, thus reflecting a negligible effect of these extrapolations at global and regional scales. At country scale, some bias may exist if one energy source was associated with a sharp increase or decrease between the years 2010 and 2011. This is however not deemed the case for most countries (due to the time required to install and deploy specific technologies), and is thus not expected to compromise the interpretation of the results.

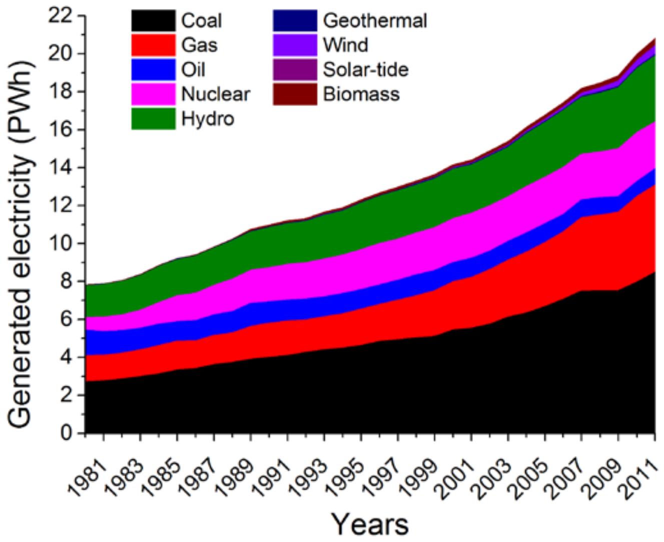


Fig. SM1. Global generated electricity between 1980 and 2011 per energy sources.

<u>Life cycle inventories and impact assessment</u>

The overall approach consisted in assessing life cycle inventories of unitary electricity generation activities (i.e. resource and emission inventories scaled to the generation of 1 kWh) with the selected life cycle impact assessment (LCIA) method. The life cycle inventories were taken from ecoinvent 3.01 database.[3-5] Electricity generation activities are classified per type of energy sources used. Some adaptations were necessary to ensure a matching between the collected electricity data and the available life cycle inventories; this was done using production volumes for the year 2008 (see Section 2.2 in manuscript).

During the course of the work, the ecoinvent 3.01 has been recognised to contain some inconsistencies by its developers. A new version of the ecoinvent database (ecoinvent 3.1) has thus been developed and released.[6] At the time of study, the ecoinvent 3.1 database was not available in professional LCA software (e.g. SimaPro[7] used in this study). However, a check between the two versions with a specific focus on the electricity generation processes showed that differences were primarily associated with the renewable energy flows (not considered in this study) and the water input and output flows. With regard to the latter, important inconsistencies were found to lie in the water balances of the electricity generation processes, thus compromising the results of water use assessments. This was the motivation for excluding the assessment of water use in the current study in spite of its relevance. The influence of potential inconsistencies in the background processes, e.g. production of materials for building the power plants, was not investigated because of the extensive and difficultly traceable nature of the multi-layer networks of processes behind each electricity generation system.

The study is an accounting-type study, where the main objective is to document the environmental impacts of electricity generation between 1980 and 2011 and inform policy-makers about the results of that retrospective assessment. According to the International Reference Life Cycle Data System (ILCD) Handbook, which provides detailed guidance on the conduct of LCA, the study falls within a situation C1context.[8] Interactions with other external systems, e.g. including recycling benefits or avoided production for co-products, were included as this approach is deemed to better capture reality (compared to an accounting, in which the analysed system is taken in isolation). This choice refers to the difference between attributional and consequential modelling, which has been a continuous source of debate in the LCA community (e.g. Refs. 9, 10). Consequential LCA differs from attributional LCA in two ways: (1) the processes included are those which are most likely to respond to a change in demand, and (2) co-product allocation is avoided by system expansion.[11] (Schmidt and Weidema, 2008). Ecoinvent 3 database offers the opportunity to select either consequential or attributional modelling approach. In the present study, the consequential ecoinvent 3 database was chosen as it better matches the context situation (situation C1). However, it shall be mentioned that the consequential ecoinvent 3 database is specifically suited for situation B studies and is not fully consistent with situation A or C1 studies (e.g. use of marginal data versus average data). On-going work currently focuses on building a database that specifically matches these 2 situations, but it was not available yet at the time of study.

In the association of electricity data with life cycle inventories, a number of assumptions were necessary. These are reported per type of energy sources in Table SM1.

Table SM1. Life cycle inventory modelling assumptions per type of energy sources

Energy source	**Modelling assumptions**
Coal	The collected electricity data aggregate electricity produced from hard coal and brown coal (or lignite). The LCIs are differentiated for a few countries. Therefore, where applicable, the country-specific ratios between the production volumes in 2008 of electricity from both sources were used to split the total electricity generated from coal sources.
Natural gas	Conventional power plants are considered although today most of the natural gas power plants are designed with combined cycles.[4] Because the study focuses on a retrospective analysis (over the last 32 years), this is considered a fair assumption. To support this assumption, it shall be added that, for most of the countries (with some exceptions like Canada), in 2008, conventional plants dominated and the use of combined cycles was relatively minor (e.g. for the world without the 50 countries covered in ecoinvent 3: conventional power plants account for 87%). Data are also not homogeneously available with regard to combined cycle power plants.
Nuclear	Allocation is made between Boiling Water Reactor (BWR) and Pressurized Water Reactor (PWR) using the production volumes of 2008 reported in ecoinvent 3.

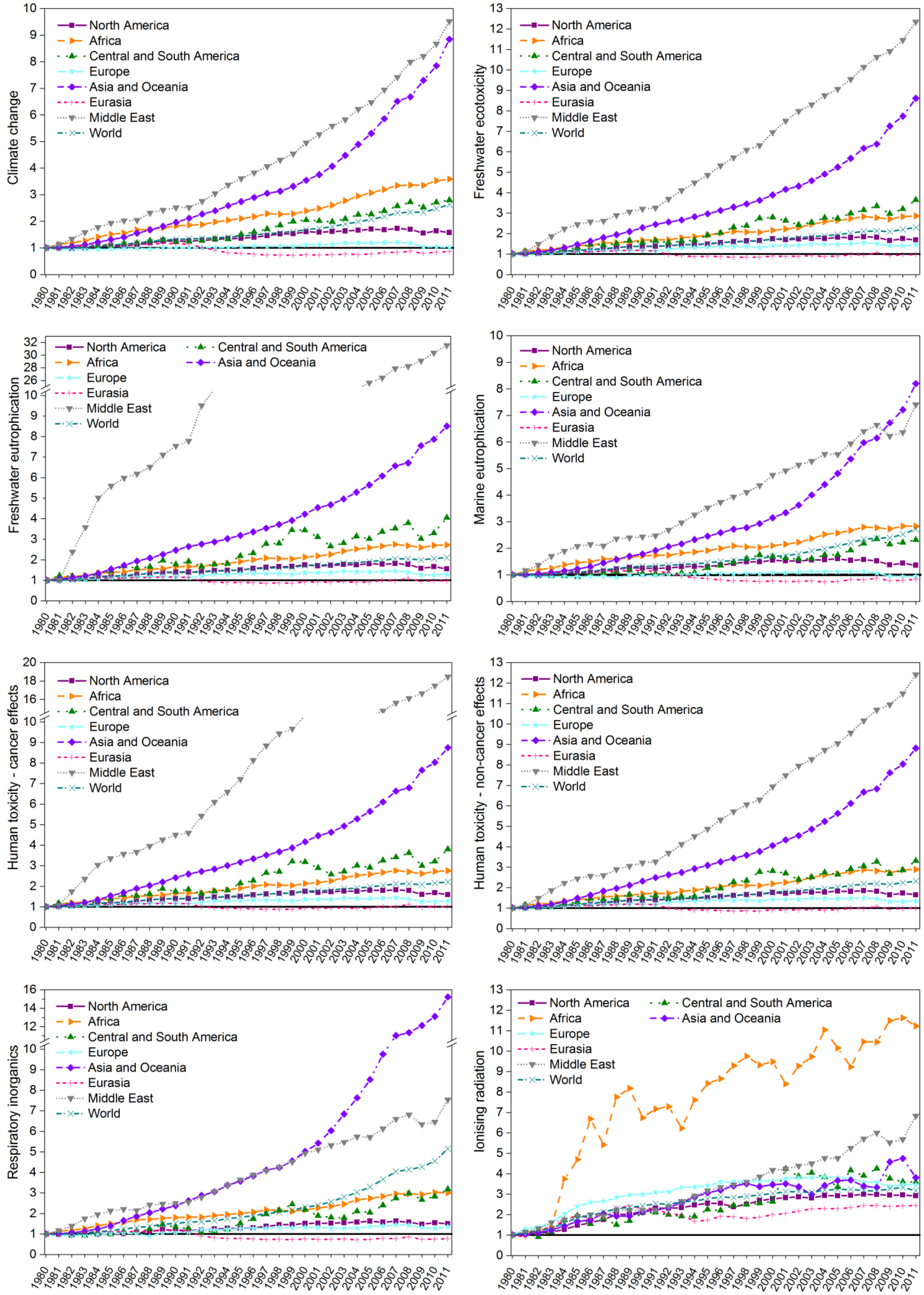
Hydropower	Allocation is made between run-of-river and reservoir using the production volumes of 2008 reported in ecoinvent 3.
Wind	Apportionment is made based on production volume of 2008 (capacity and on-shore/off-shore).
Solar	Allocation is made based on production volume of 2008 (capacity and type of installation, e.g. roof, façade…). Electricity from tidal energy is approximated with solar technologies. This is considered a minor assumption due to the negligible proportion of tidal energy use.
Biomass	Electricity from biomass is modelled as electricity produced from biogas originating from biowaste and sludge. In the absence of sufficient data to reunite electricity from biomass with regard to LCIs, co-generated electricity from the burning of wood by-products was assumed to be represented by these processes. The LCI process for the treatment of 1 m^3 of biogas was adapted so that it produced 1 kWh of electricity.

Supplementary Results and Discussion

This section includes:

- Supplementary Figures S1-S5
- Supplementary Tables S1-S3 *

* Because of layout constraints, Tables S4-S6 are reported in Electronic Supporting Information ESI-2 (Microsoft Excel file).


Climate change
Freshwater ecotoxicity
Freshwater eutrophication
Marine eutrophication
Human toxicity - cancer effects
Human toxicity - non-cancer effects
Respiratory inorganics
Ionising radiation
North America
Africa
Central and South America
Europe
Asia and Oceania
Eurasia
Middle East
World
1980
1981
1982
1983
1984
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1986
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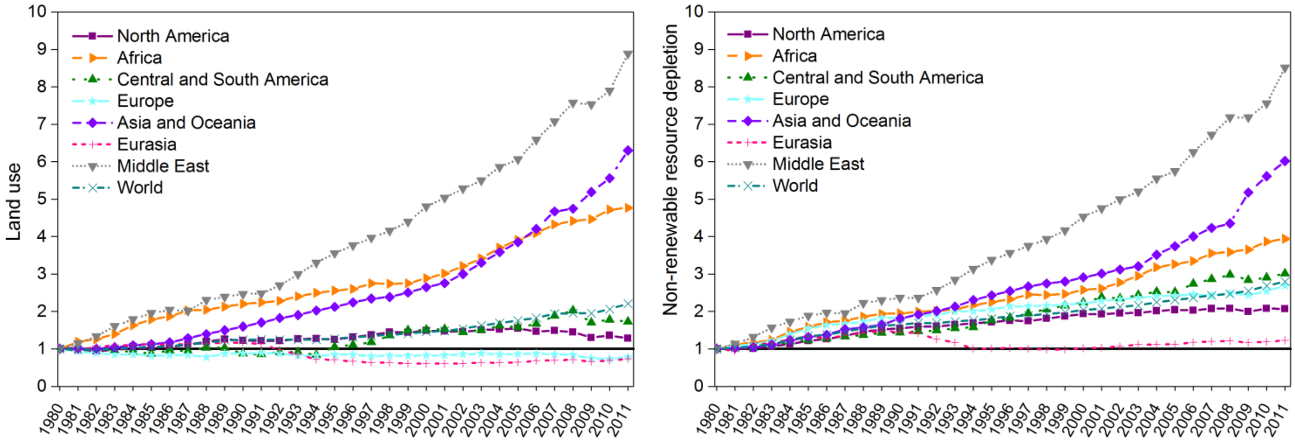
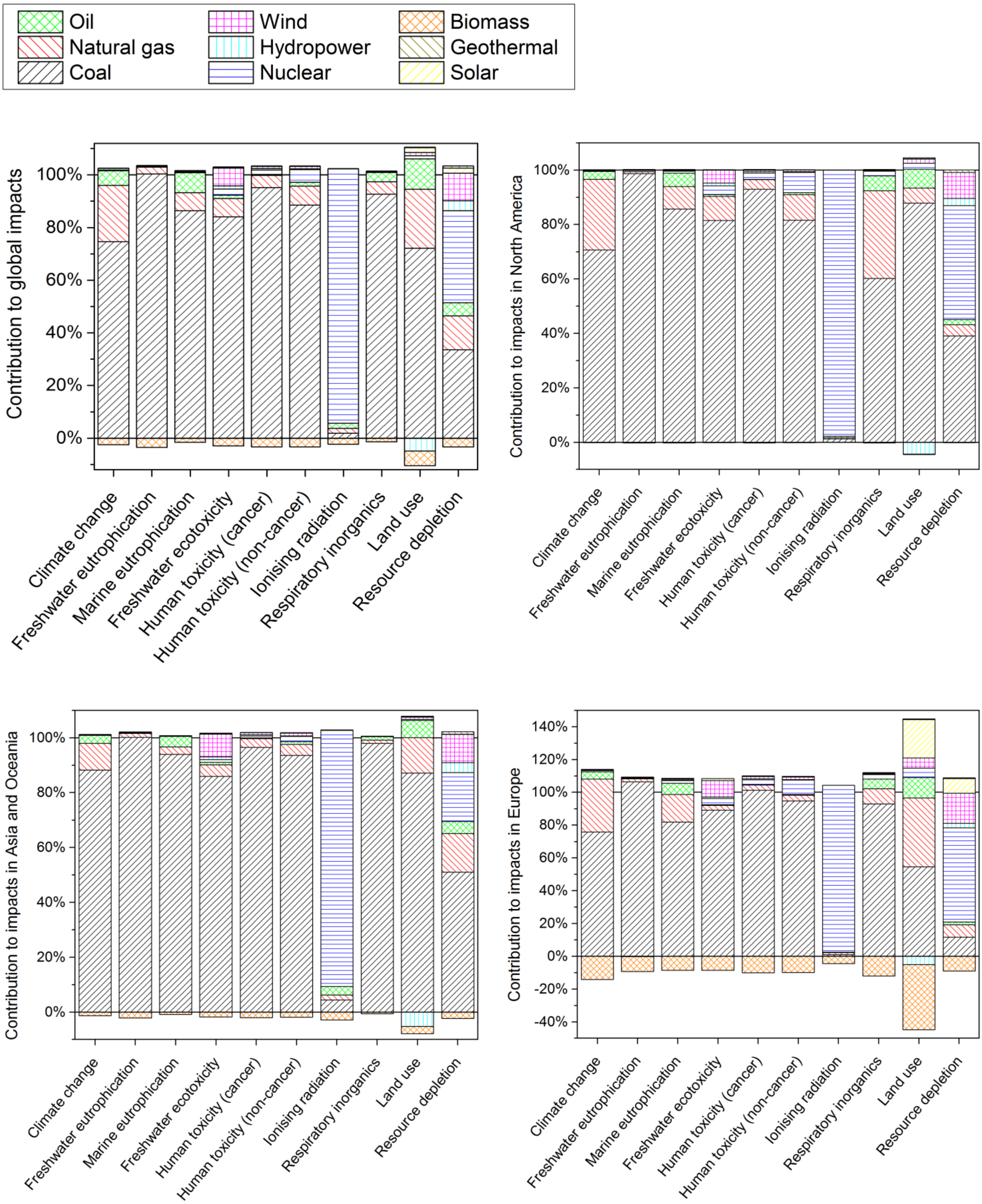


Fig. S1. Global and regional impact trends for each impact category between 1980 and 2011.

Impact scores in 1980 were taken as baseline, against which the impact scores for the other years were divided (1980 baseline symbolized by a straight black line y=1 on the graphs). Note that the scale of the y-axes differs between the graphs although some degree of harmonization was attempted to facilitate comparisons across impact categories. Asia and the Middle East are the regions for which the largest increases are observed. With the exception of ionizing radiation, this tendency applies to all impact categories with some of them being associated with increases of more than one order of magnitude from the impact level of 1980. Note that these graphs represent the relative trends of the impacts and do not give indications of the magnitude of the impacts. A region may thus be associated with important increase in a given impact category (e.g. as a result of an important change in the energy policy), but still have an impact score that remains low relative to other regions. Fig. S4 illustrates how the magnitude of the impact scores can be evaluated.


Oil
Natural gas
Coal
Wind
Hydropower
Nuclear
Biomass
Geothermal
Solar
Contribution to global impacts
Contribution to impacts in North America
Contribution to impacts in Asia and Oceania
Contribution to impacts in Europe
Climate change
Freshwater eutrophication
Marine eutrophication
Freshwater ecotoxicity
Human toxicity (cancer)
Human toxicity (non-cancer)
Ionising radiation
Respiratory inorganics
Land use
Resource depletion

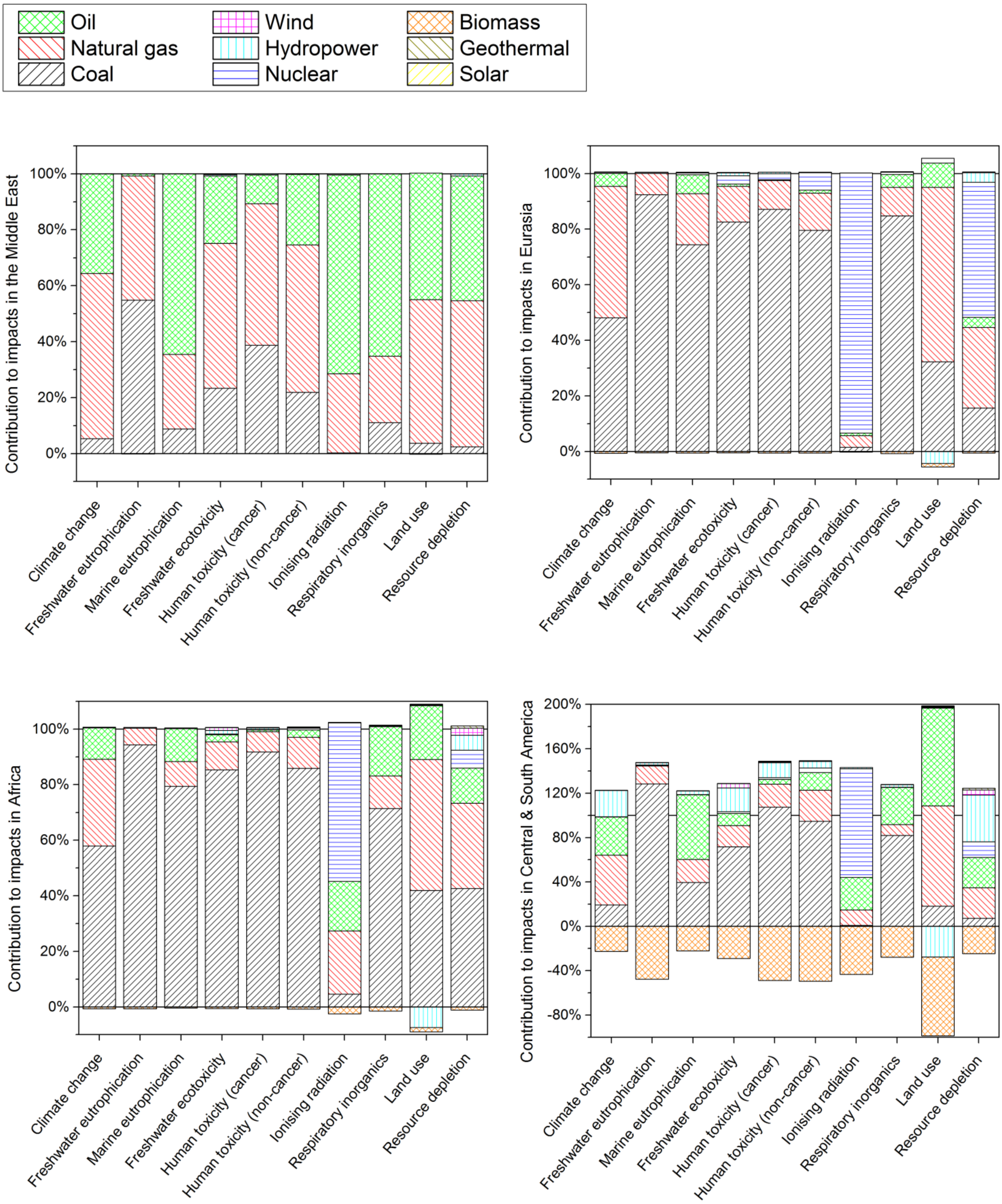
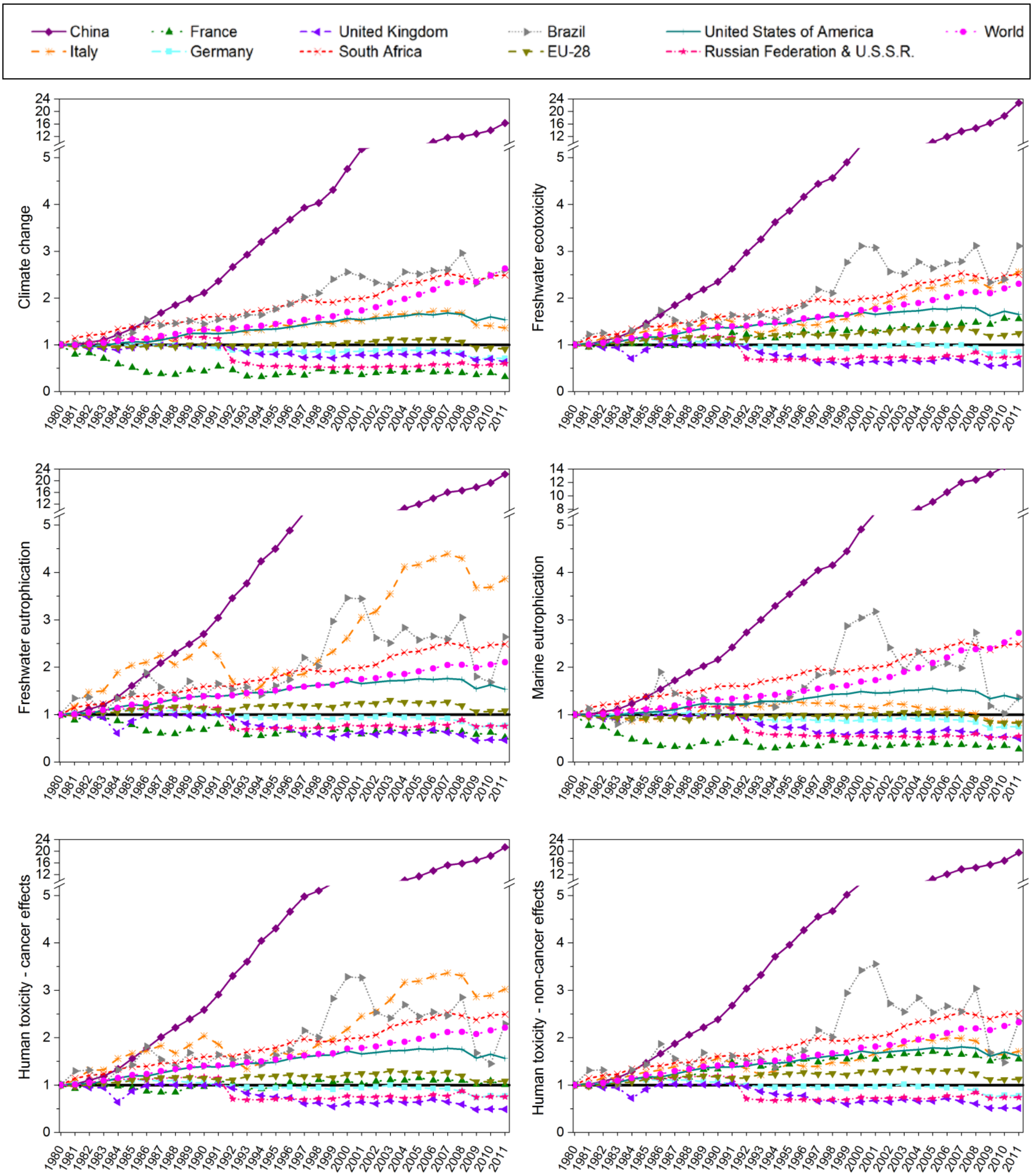


Fig. S2. Contribution of different energy sources to global and regional impacts in 2011.

In addition to the global impact contribution analysis (identical to the one in Fig. 1), seven regions are considered here: North America, Europe, Asia and Oceania, Middle East, Eurasia, Africa, Central and South America. Regional variations can be observed in the distribution of the impact scores across energy sources. While Europe, North America, Asia and Oceania, and Eurasia share a similar pattern, with a significant contribution of coal energy sources in most impact categories, the

Middle East and Central and South America show different profiles. The mix of energy sources in the Middle East is largely composed of oil and natural gas, which dictates the observed distribution. In Central and South America, the large use of hydropower and biomass is reflected in the results. The negative results from the biomass sources are representative for the savings from the avoided generation of electricity produced by conventional sources, e.g. from oil energy sources. In particular, this has substantial influence on the land use assessments, which have negative components whenever biomass is used to generate electricity in a given region. To a broader extent, this also illustrates the environmental benefits that could be gained from the utilisation of biowaste for electricity generation (which was used as proxy for electricity produced from biomass sources). Two other impact categories, i.e. ionising radiation and non-renewable resource depletion, also show atypical patterns in their distributions. Ionising radiation impacts on human health mainly stem from the use of nuclear energy sources, explaining its large contributions in regions embodying nuclear power. Non-renewable resource depletion shows a more spread-out distribution pattern, with contributions from fossils-based energy sources but also from nuclear power and renewables like wind power (e.g. Asia, Europe, North America) and solar energy (e.g. Europe). The characterisation model used for the assessment is a scarcity-based indicator relying on the reserve base of each resource (resources that have a reasonable potential for becoming economically available within planning horizons beyond those that assume proven technology and current economics; Oers et al.[12]). The depletion of uranium is the main cause for the substantial contribution of nuclear energy sources in the impact indicator scores. The wind and solar power sources contribute via the important use of metals required for the manufacture of the facility/equipment (e.g. wind turbines, solar cells, etc.).


China
France
United Kingdom
Brazil
United States of America
World
Italy
Germany
South Africa
EU-28
Russian Federation & U.S.S.R.
Climate change
Freshwater ecotoxicity
Freshwater eutrophication
Marine eutrophication
Human toxicity - cancer effects
Human toxicity - non-cancer effects

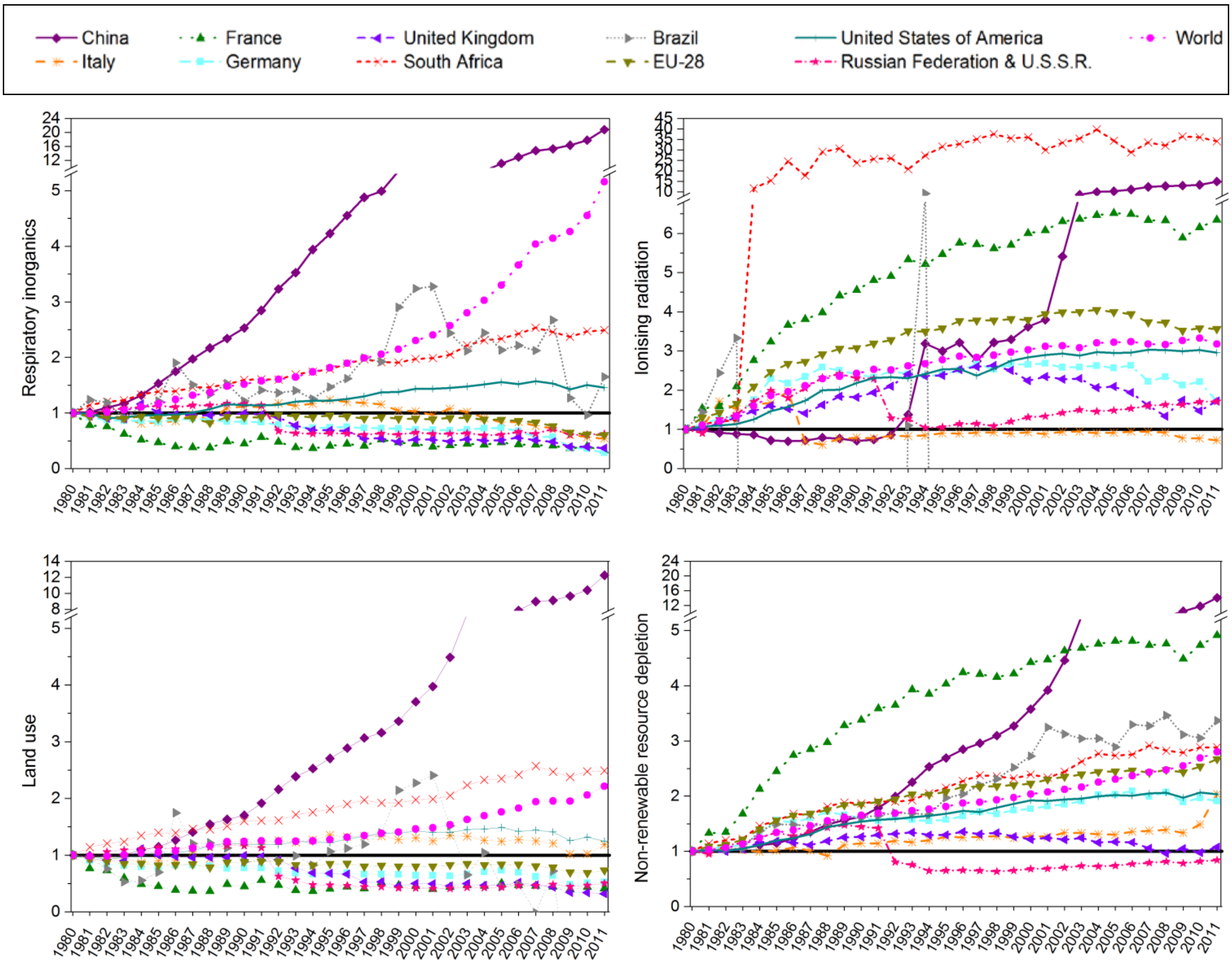
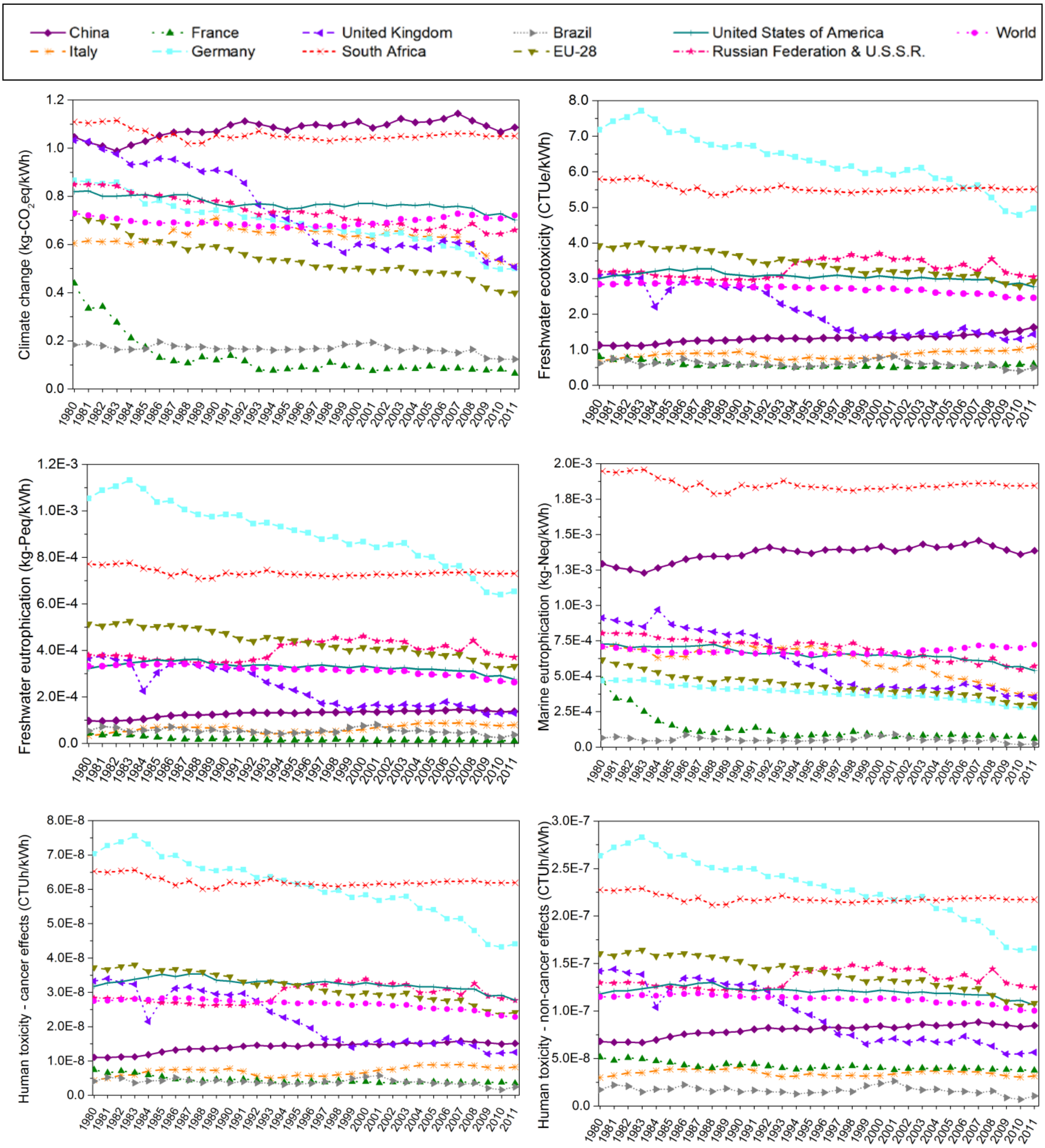


Fig. S3. Impact trends of 11 selected countries/regions over the period 1980-2011 (trends indexed on the year 1980) for each impact category (total of 10 categories).

Impact scores in 1980 were taken as baseline, against which the impact scores for the other years were divided (1980 baseline symbolized by a straight black line y=1 on the graphs). Note that the scale of the y-axes differs between the graphs although some degree of harmonization was attempted to facilitate comparisons across impact categories. It is observed that, for the 32-year period considered, with the exception of Russia and, to a lesser extent, United Kingdom (when disregarding ionising radiation), no country has been associated with a consistent reduction of its environment impacts. The decreasing trends observed for Russia when indexing on the year 1980 stem from the Fall of Communism; however, it can be noted that most of the impacts have increased since 1991. Also noticeable on the figure are the trends observed for ionising radiation, which tend to be positive for nearly all countries/regions considered. The indicator scores for that impact category are strongly dependent on the nuclear power landscape of the country. For Brazil, sudden changes occur in the impact results for ionising radiation, which are explained by matching drops and rises in the data for electricity generated by nuclear power extracted from the Data Shift project (2014).[1] These results should therefore be considered with caution as inconsistencies in the original electricity data for nuclear power in Brazil can be expected. As in several countries in the Asia and the Middle East, China is associated with booming impacts from electricity production. All impacts have thus increased by more than a factor of 10, and 6 impact categories have shown increases superior to a factor of 20, i.e. human toxicity (both non cancer and cancer), particulate matter, ionizing radiation, freshwater eutrophication and freshwater ecotoxicity. In contrast, disparate increases in developed countries such as Europe and North America appear with either moderate increases, stabilisation or decreases in recent years depending on the impact category (flattening or negative increase rate). In addition to the burden-shifting associated with such nuanced trends, those results clearly reflect the two different speeds at which national environmental burdens are increasing in the world (see Sections 3.2 and 3.3 in the manuscript).


China
France
United Kingdom
Brazil
United States of America
World
Italy
Germany
South Africa
EU-28
Russian Federation & U.S.S.R.
Climate change (kg-CO$_2$eq/kWh)
Freshwater ecotoxicity (CTUe/kWh)
Freshwater eutrophication (kg-Peq/kWh)
Marine eutrophication (kg-Neq/kWh)
Human toxicity - cancer effects (CTUh/kWh)
Human toxicity - non-cancer effects (CTUh/kWh)

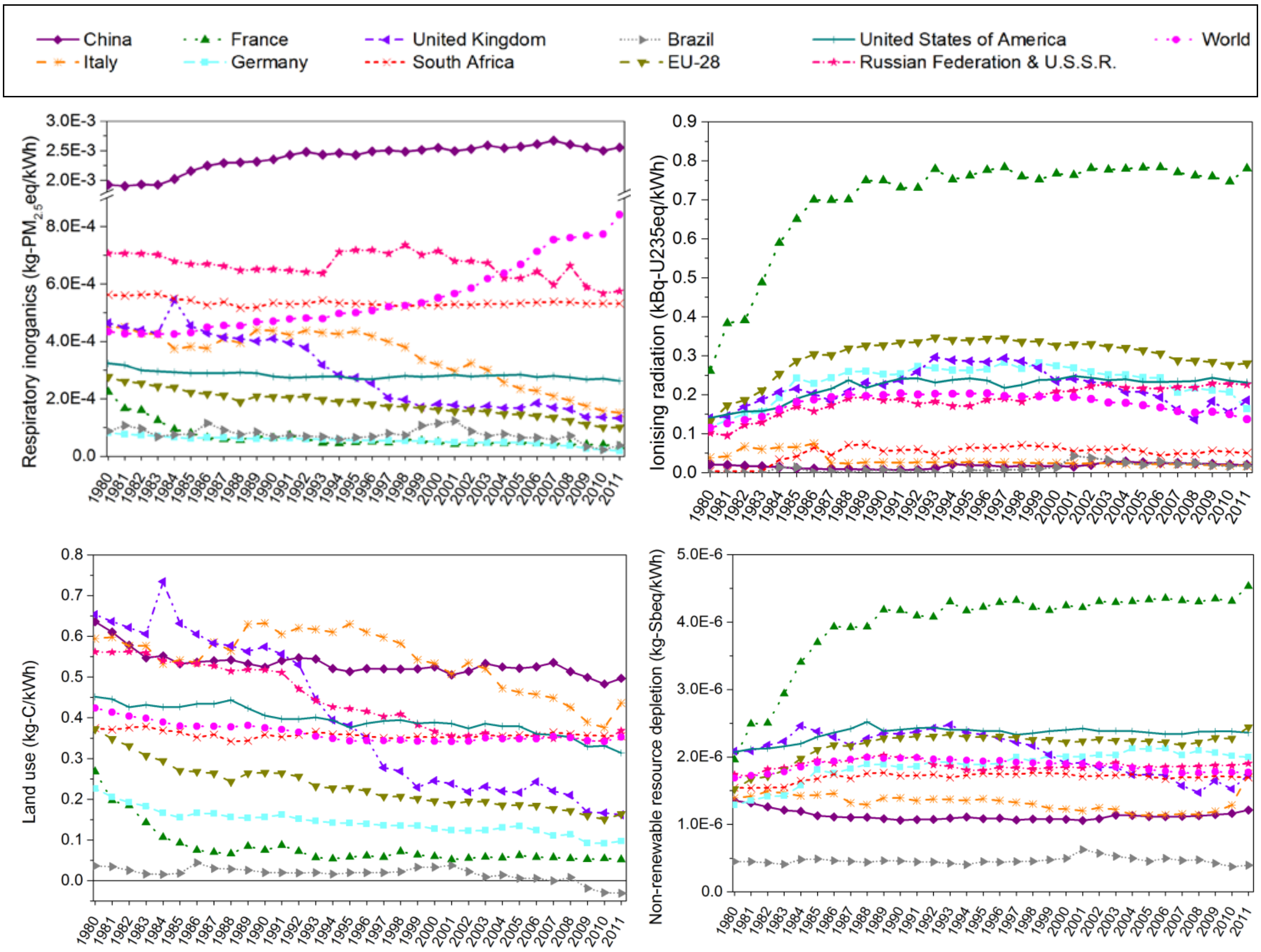
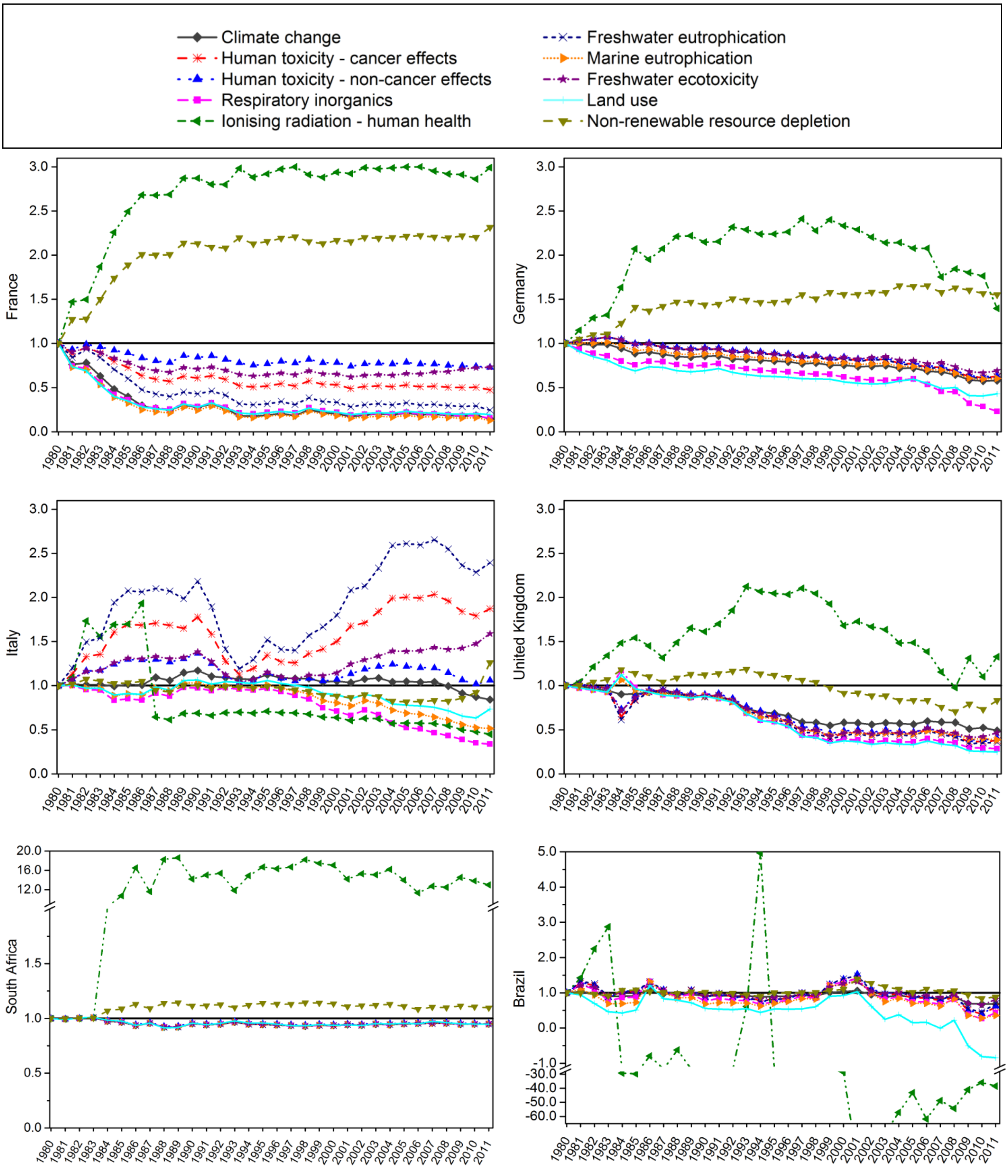


Fig. S4. Impact intensities for 11 selected countries/regions over the period 1980-2011 classified per impact category (total of 10 impact categories).

The impact intensities reflect the “cleanness” of national electricity mixes and are expressed in units specific to each impact category scaled to the generation of 1 kWh of electricity. To support the reading of those graphs, trends of these impact intensities over 1980-2011 (indexed to the year 1980) are also provided for each selected country in Fig. S5. With few exceptions, e.g. countries with large share of hydropower like Brazil, no country or region shows systematically high or low impact intensities for all impact categories. This observation reflects that the diversity of the grid mixes has a strong importance on the magnitude of the impacts, and that assessment and interpretation of the environmental impacts of electricity generation systems should be done at a national scale. For a given country, impact intensities that are situated above the global mean curve (in pink) could be interpreted as impact categories that would require attention from policy-makers (see Section 4.2).



Climate change
Human toxicity - cancer effects
Human toxicity - non-cancer effects
Respiratory inorganics
Ionising radiation - human health
Freshwater eutrophication
Marine eutrophication
Freshwater ecotoxicity
Land use
Non-renewable resource depletion
France
Germany
Italy
United Kingdom
South Africa
Brazil

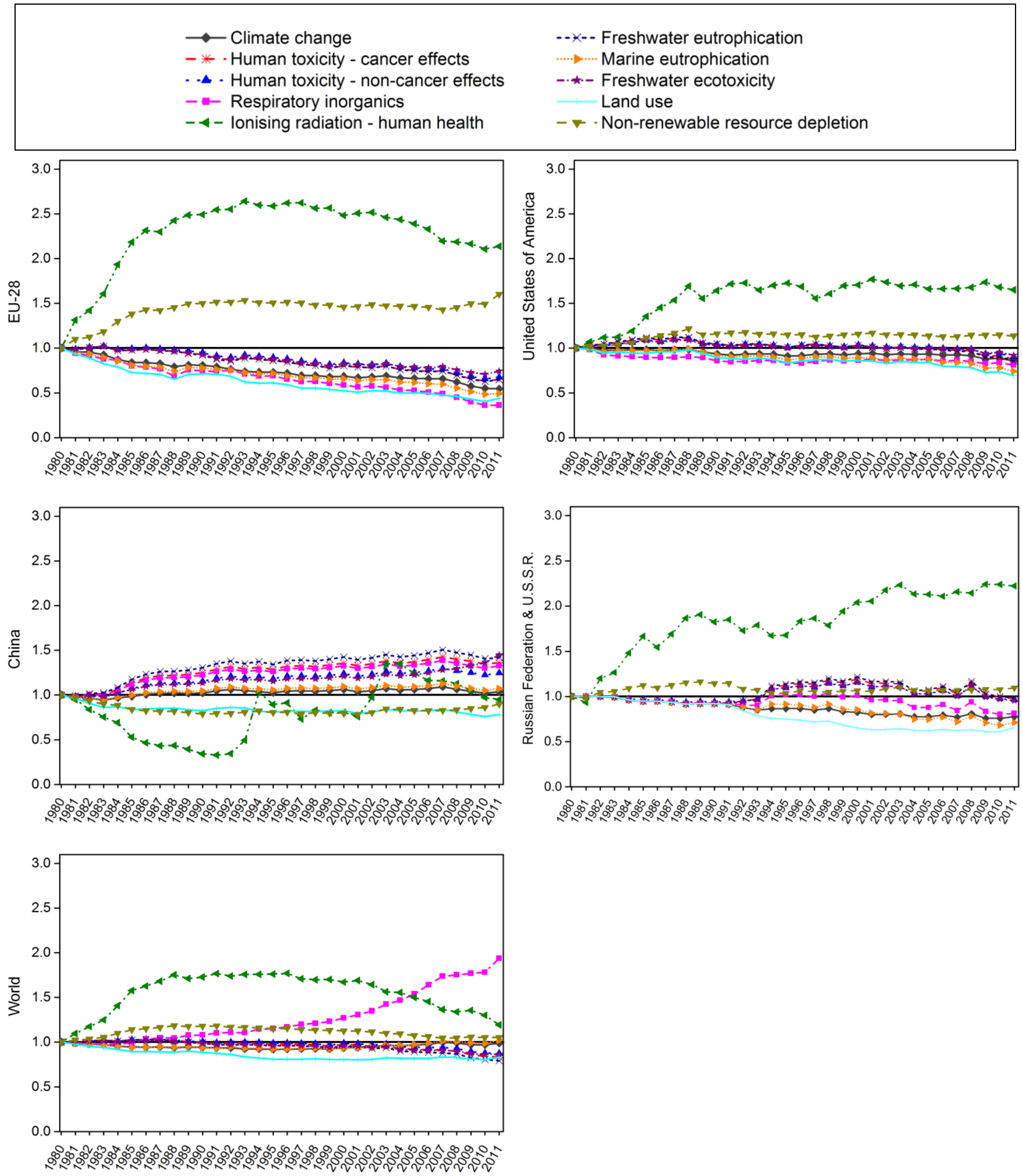


Fig. S5. Trends of impact intensities over 1980-2011 (baseline: 1980) for ten impact categories for 11 selected countries/regions.

The same countries and regions as in Fig. S4 are included (1980 baseline symbolized by a straight black line y=1 on the graphs). Note that the y-scale is different for South Africa and Brazil due to the important variations in ionising radiation impact scores. For Brazil, as in Fig. S3, sudden changes in the impact results for ionising radiation are explained by matching drops and rises in the data for electricity generated by nuclear power extracted from the Data Shift project (2014);[1] these results should therefore be considered with caution as inconsistencies in the original electricity data for nuclear power in Brazil seem likely to have occurred. The figure show the contrast between the European countries and USA, for which most impacts, including climate change, tend to decrease, and developing countries, such as China or South Africa, for which impacts generally tend to increase or stagnate. Two major trends can therefore be observed worldwide (see Section 3.3 in the manuscript). Furthermore, the figures generally illustrate that, with the exception of ionising radiation, land use and non-renewable resource depletion, several of the other impact categories co-vary over time although nuances exist for some countries (e.g. Italy). This may indicate that some degree of correlation may exist across some impact categories for individual countries. In future studies, these patterns could be investigated as they could help reduce the number of impact categories to assess and support the definition of key environmental indicators at national level. Such definitions must however be done with great caution to prevent the incidence of burden-shifting, i.e. by inadvertently removing an impact category that would not co-vary with any of the retained impacts.

Table S1. Regional trends and per-capita impact scores for the impacts stemming from electricity generation for the 10 selected impact categories. [a]

Impact category	Per-capita impact score 2011	Unit	Global trend (absolute values) (%)	Trend (per-capita values) (%)			
			1980-2011	1980-1990	1990-2000	2000-2010	1980-2011
North America							
Climate change	6.90E+03	kg-CO_2eq/pers	58%	11%	12%	-7%	8%
Freshwater eutrophication	2.67E+00	kg-Peq/pers	56%	24%	10%	-14%	7%
Marine eutrophication	5.38E+00	kg-Neq/pers	36%	11%	8%	-16%	-4%
Freshwater ecotoxicity	2.72E+04	CTUe/pers	69%	22%	11%	-9%	14%
Human toxicity (cancer effects)	2.67E-04	CTUh/pers	59%	23%	10%	-13%	8%
Human toxicity (non-cancer effects)	1.04E-03	CTUh/pers	65%	23%	11%	-11%	11%
Ionising radiation (human health)	2.30E+03	kBq-U_{235}eq/pers	192%	91%	12%	-3%	48%
Respiratory inorganics	2.66E+00	kg-$PM_{2.5}$eq/pers	50%	4%	12%	-7%	4%
Land use	3.05E+03	kg-C/pers	28%	8%	7%	-17%	-9%
Non-renewable resource depletion	2.38E-02	kg-Sb_{eq}/pers	107%	37%	9%	-3%	30%
Europe							
Climate change	2.31E+03	kg-CO_2eq/pers	2%	-4%	-1%	-11%	-18%
Freshwater eutrophication	2.06E+00	kg-Peq/pers	29%	11%	5%	-12%	4%
Marine eutrophication	1.82E+00	kg-Neq/pers	-5%	-7%	-1%	-18%	-26%
Freshwater ecotoxicity	1.79E+04	CTUe/pers	46%	11%	7%	-5%	15%
Human toxicity (cancer effects)	1.48E-04	CTUh/pers	28%	11%	4%	-12%	3%
Human toxicity (non-cancer effects)	6.69E-04	CTUh/pers	34%	14%	6%	-12%	7%
Ionising radiation (human health)	1.48E+03	kBq-U_{235}eq/pers	246%	184%	9%	-9%	56%
Respiratory inorganics	1.26E+00	kg-$PM_{2.5}$eq/pers	36%	2%	10%	-9%	9%
Land use	8.94E+02	kg-C/pers	-22%	-16%	-16%	-16%	-52%
Non-renewable resource depletion	1.32E-02	kg-Sb_{eq}/pers	169%	74%	8%	9%	61%
Middle East							
Climate change	3.30E+03	kg-CO_2eq/pers	851%	75%	57%	39%	109%
Freshwater eutrophication	2.20E-01	kg-Peq/pers	3055%	423%	106%	24%	108%
Marine eutrophication	2.41E+00	kg-Neq/pers	641%	69%	55%	7%	83%
Freshwater ecotoxicity	3.83E+03	CTUe/pers	1135%	122%	72%	31%	107%
Human toxicity (cancer effects)	2.36E-05	CTUh/pers	1746%	212%	89%	30%	110%
Human toxicity (non-cancer effects)	1.70E-04	CTUh/pers	1141%	123%	72%	32%	108%
Ionising radiation (human health)	1.11E+02	kBq-U_{235}eq/pers	583%	54%	50%	9%	85%
Respiratory inorganics	1.29E+00	kg-$PM_{2.5}$eq/pers	653%	73%	57%	4%	82%
Land use	2.58E+03	kg-C/pers	789%	71%	55%	31%	104%
Non-renewable resource depletion	5.76E-03	kg-Sb_{eq}/pers	751%	64%	53%	33%	104%

Impact category	Per-capita impact score 2011	Unit	Global trend (absolute values) (%)	Trend (per-capita values) (%)			
			1980-2011	1980-1990	1990-2000	2000-2010	1980-2011
Eurasia							
Climate change	3.30E+03	kg-CO_2eq/pers	-13%	7%	-36%	12%	-29%
Freshwater eutrophication	1.67E+00	kg-Peq/pers	-2%	7%	-19%	5%	-11%
Marine eutrophication	3.00E+00	kg-Neq/pers	-17%	7%	-33%	2%	-33%
Freshwater ecotoxicity	1.38E+04	CTUe/pers	-3%	8%	-22%	5%	-13%
Human toxicity (cancer effects)	1.28E-04	CTUh/pers	1%	8%	-19%	6%	-8%
Human toxicity (non-cancer effects)	5.75E-04	CTUh/pers	-1%	10%	-22%	6%	-11%
Ionising radiation (human health)	1.12E+03	kBq-U_{235}eq/pers	144%	113%	-12%	20%	65%
Respiratory inorganics	2.46E+00	kg-$PM_{2.5}$eq/pers	-22%	7%	-34%	-2%	-41%
Land use	1.86E+03	kg-C/pers	-26%	7%	-47%	12%	-56%
Non-renewable resource depletion	9.58E-03	kg-Sb_{eq}/pers	23%	33%	-28%	15%	14%
Asia and Oceania							
Climate change	2.11E+03	kg-CO_2eq/pers	785%	64%	56%	99%	174%
Freshwater eutrophication	5.81E-01	kg-Peq/pers	751%	106%	48%	67%	138%
Marine eutrophication	2.45E+00	kg-Neq/pers	720%	49%	53%	105%	179%
Freshwater ecotoxicity	5.42E+03	CTUe/pers	761%	92%	47%	78%	152%
Human toxicity (cancer effects)	5.20E-05	CTUh/pers	775%	102%	49%	73%	145%
Human toxicity (non-cancer effects)	2.40E-04	CTUh/pers	782%	94%	51%	78%	150%
Ionising radiation (human health)	1.33E+02	kBq-U_{235}eq/pers	281%	78%	41%	23%	58%
Respiratory inorganics	3.72E+00	kg-$PM_{2.5}$eq/pers	1422%	99%	83%	134%	226%
Land use	1.04E+03	kg-C/pers	530%	33%	44%	88%	155%
Non-renewable resource depletion	3.24E-03	kg-Sb_{eq}/pers	502%	52%	39%	73%	133%
Africa							
Climate change	4.61E+02	kg-CO_2eq/pers	259%	39%	3%	14%	42%
Freshwater eutrophication	1.97E-01	kg-Peq/pers	173%	26%	1%	-2%	18%
Marine eutrophication	5.75E-01	kg-Neq/pers	183%	31%	-4%	4%	22%
Freshwater ecotoxicity	1.63E+03	CTUe/pers	187%	28%	1%	1%	22%
Human toxicity (cancer effects)	1.70E-05	CTUh/pers	175%	26%	1%	-1%	19%
Human toxicity (non-cancer effects)	6.40E-05	CTUh/pers	189%	29%	1%	1%	23%
Ionising radiation (human health)	1.92E+01	kBq-U_{235}eq/pers	1023%	412%	10%	-5%	83%
Respiratory inorganics	1.99E-01	kg-$PM_{2.5}$eq/pers	201%	37%	-5%	7%	27%
Land use	2.28E+02	kg-C/pers	377%	67%	3%	26%	65%
Non-renewable resource depletion	8.38E-04	kg-Sb_{eq}/pers	294%	48%	4%	16%	51%
Central and South America							
Climate change	6.03E+02	kg-CO_2eq/pers	179%	-1%	43%	18%	52%

Impact category	Per-capita impact score 2011	Unit	Global trend (absolute values) (%)	Trend (per-capita values) (%)			
			1980-2011	1980-1990	1990-2000	2000-2010	1980-2011
Freshwater eutrophication	1.12E-01	kg-Peq/pers	305%	46%	64%	-14%	70%
Marine eutrophication	4.63E-01	kg-Neq/pers	131%	-13%	35%	17%	37%
Freshwater ecotoxicity	1.47E+03	CTUe/pers	265%	27%	52%	2%	69%
Human toxicity (cancer effects)	9.54E-06	CTUh/pers	280%	43%	55%	-10%	67%
Human toxicity (non-cancer effects)	4.35E-05	CTUh/pers	231%	24%	57%	-10%	56%
Ionising radiation (human health)	4.67E+01	kBq-U_{235}eq/pers	258%	71%	7%	22%	41%
Respiratory inorganics	4.43E-01	kg-$PM_{2.5}$eq/pers	218%	9%	40%	15%	74%
Land use	2.10E+02	kg-C/pers	73%	-29%	48%	5%	6%
Non-renewable resource depletion	1.58E-03	kg-Sb_{eq}/pers	202%	17%	33%	15%	52%

[a] Cells marked in grey are accelerating trends (i.e. higher percentages than in the previous decade).

Table S2. Regional normalised per-capita impact scores for 2011 (normalisation within global electricity generation sector) [a,b]

Regions	Climate change	Freshwater eutrophic-cation	Marine eutrophic-cation	Freshwater ecotoxicity	Human toxicity (cancer effects)	Human toxicity (non-cancer effects)	Ionising radiation (human health)	Respiratory inorganics	Land use	Non-renewable resource depletion
North America	3.15	3.35	2.45	3.65	3.86	3.42	5.53	1.05	2.85	4.42
Africa	0.21	0.25	0.27	0.22	0.25	0.21	0.05	0.08	0.22	0.16
Central and South America	0.28	0.14	0.21	0.20	0.14	0.14	0.11	0.17	0.20	0.29
Europe	1.06	2.60	0.83	2.41	2.15	2.21	3.58	0.49	0.84	2.46
Asia and Oceania	0.96	0.73	1.11	0.73	0.75	0.79	0.32	1.46	0.98	0.60
Eurasia	1.53	2.12	1.39	1.88	1.88	1.92	2.72	0.98	1.76	1.81
Middle East	1.54	0.28	1.12	0.52	0.35	0.57	0.27	0.52	2.46	1.09

[a] Normalised scores are obtained by dividing the per-capita impact score obtained for a given region and impact category by the global per-capita impact score. Normalised scores above 1 are marked in grey.

[b] Normalised results at national scale are available in Table S3.

Table S3. Regional normalised per-capita impact scores for 2011 (normalisation within global electricity generation sector) [a,b]

Countries	Climate change	Fresh-water eutrophi-cation	Marine eutrophi-cation	Fresh-water eco-toxicity	Human toxicity (cancer effects)	Human toxicity (non-cancer effects)	Ionising radiation (human health)	Respira-tory inor-ganics	Land use	Non-renew-able resource depletion
Africa										
Mali	0.006	0.001	0.004	0.002	0.002	0.002	0.001	0.002	0.006	0.006
Democratic Republic of the Congo	0.001	0.000	0.001	0.003	0.001	0.001	0.000	0.000	-0.015	0.008
Swaziland	0.105	0.195	0.124	0.159	0.172	0.158	0.001	0.073	0.088	0.048
Chad	0.003	0.001	0.002	0.001	0.001	0.001	0.001	0.001	0.005	0.002
Sao Tome and Principe	0.056	0.094	0.064	0.077	0.083	0.078	0.002	0.037	0.057	0.025
Egypt	0.520	0.096	0.289	0.185	0.124	0.175	0.104	0.122	0.800	0.434
Congo	0.005	0.001	0.003	0.004	0.002	0.002	0.001	0.001	-0.010	0.012
Ethiopia	0.002	0.000	0.003	0.002	0.001	0.001	0.001	0.001	-0.007	0.007
Réunion	0.397	0.815	0.546	0.699	0.692	0.617	-0.165	0.231	0.105	0.051
Gambia	0.067	0.113	0.076	0.091	0.099	0.093	0.002	0.044	0.077	0.025
Libyan Arab Jamahiriya	1.964	0.237	1.622	0.561	0.335	0.581	0.496	0.708	3.216	1.526
Cape Verde	0.282	0.476	0.322	0.383	0.417	0.390	0.009	0.184	0.326	0.104
Burkina Faso	0.017	0.029	0.020	0.023	0.025	0.024	0.001	0.011	0.019	0.007
Angola	0.041	0.001	0.053	0.015	0.005	0.010	0.014	0.024	0.039	0.050
Somalia	0.016	0.027	0.018	0.022	0.024	0.022	0.001	0.011	0.019	0.006
Namibia	0.033	0.047	0.039	0.054	0.048	0.042	0.003	0.022	-0.052	0.062
Mozambique	0.003	0.001	0.003	0.017	0.009	0.003	0.001	0.002	-0.096	0.054
Ghana	0.010	0.002	0.004	0.010	0.006	0.004	0.002	0.002	-0.027	0.029
Sierra Leone	0.004	0.006	0.004	0.006	0.006	0.005	0.000	0.003	0.000	0.004
Cameroon	0.027	0.001	0.029	0.012	0.005	0.007	0.008	0.013	0.013	0.038
Tunisia	0.488	0.112	0.174	0.176	0.135	0.176	0.079	0.068	0.752	0.379
United Republic of Tanzania	0.014	0.002	0.006	0.006	0.003	0.005	0.001	0.003	-0.001	0.012
Zimbabwe	0.179	0.331	0.213	0.271	0.293	0.269	0.002	0.124	0.147	0.085
Gabon	0.237	0.032	0.184	0.080	0.048	0.073	0.057	0.080	0.319	0.217
Guinea-Bissau	0.019	0.032	0.022	0.026	0.028	0.026	0.001	0.012	0.022	0.007
Algeria	0.418	0.089	0.176	0.138	0.109	0.146	0.073	0.071	0.647	0.309
Liberia	0.044	0.074	0.050	0.059	0.065	0.060	0.001	0.029	0.050	0.016
Eritrea	0.022	0.000	0.028	0.005	0.001	0.005	0.008	0.013	0.038	0.018
Djibouti	0.219	0.369	0.250	0.297	0.323	0.302	0.007	0.143	0.253	0.081
Uganda	0.012	0.022	0.015	0.019	0.020	0.018	-0.001	0.008	0.005	0.006
Kenya	0.011	-0.004	0.018	0.005	0.002	0.000	0.001	0.006	0.006	0.044
Côte d'Ivoire	0.067	0.013	0.023	0.022	0.016	0.022	0.009	0.008	0.094	0.052
Equatorial Guinea	0.075	0.127	0.086	0.102	0.111	0.104	0.003	0.049	0.087	0.028
Seychelles	1.743	2.942	1.990	2.368	2.579	2.411	0.059	1.141	2.014	0.642
Malawi	0.008	0.013	0.009	0.013	0.013	0.011	0.000	0.005	-0.007	0.011
Togo	0.001	0.000	0.002	0.001	0.000	0.000	0.000	0.001	0.000	0.002
Rwanda	0.009	0.015	0.010	0.012	0.013	0.012	0.000	0.006	0.009	0.004

Countries	Climate change	Fresh-water eutrophi-cation	Marine eutrophi-cation	Fresh-water eco-toxicity	Human toxicity (cancer effects)	Human toxicity (non-cancer effects)	Ionising radiation (human health)	Respira-tory inor-ganics	Land use	Non-renew-able resource depletion
Lesotho	0.000	0.000	0.000	0.003	0.001	0.001	0.000	0.000	-0.014	0.008
Madagascar	0.012	0.020	0.013	0.017	0.018	0.016	0.000	0.008	0.009	0.007
Central African Republic	0.002	0.003	0.002	0.003	0.003	0.003	0.000	0.001	-0.001	0.003
Benin	0.008	0.000	0.010	0.002	0.000	0.002	0.003	0.004	0.013	0.006
South Africa	2.398	4.577	4.197	3.690	4.472	3.570	0.605	1.042	1.658	1.574
Nigeria	0.048	0.008	0.028	0.016	0.011	0.016	0.010	0.012	0.069	0.040
Guinea	0.022	0.037	0.025	0.031	0.033	0.030	0.001	0.014	0.019	0.012
Mauritius	0.486	1.004	0.671	0.794	0.839	0.746	-0.206	0.283	0.231	-0.054
Botswana	0.084	0.158	0.100	0.125	0.138	0.127	0.001	0.058	0.092	0.027
Morocco	0.243	0.282	0.270	0.269	0.256	0.251	0.029	0.144	0.308	0.174
Zambia	0.005	0.002	0.005	0.022	0.011	0.005	0.001	0.003	-0.121	0.069
Senegal	0.081	-0.002	0.106	0.018	0.003	0.017	0.027	0.047	0.137	0.068
Mauritania	0.061	0.013	0.042	0.021	0.015	0.022	0.013	0.018	0.092	0.048
Burundi	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	-0.002	0.001
Sudan	0.028	-0.008	0.041	0.004	-0.005	0.000	0.006	0.015	0.031	0.028
Asia and Oceania										
Afghanistan	0.001	0.002	0.002	0.002	0.002	0.002	0.000	0.001	-0.003	0.003
Fiji	0.176	0.293	0.198	0.265	0.262	0.241	-0.005	0.108	0.120	0.126
Philippines	0.209	0.257	0.201	0.227	0.241	0.225	0.017	0.108	0.269	0.179
Sri Lanka	0.083	0.029	0.106	0.047	0.033	0.040	0.023	0.050	0.086	0.086
Solomon Islands	0.068	0.112	0.075	0.090	0.098	0.092	0.002	0.043	0.080	0.026
China	1.664	0.577	2.114	0.734	0.732	0.934	0.161	3.354	1.556	0.757
Indonesia	0.307	1.106	0.436	0.899	0.834	0.868	0.034	1.719	0.256	0.175
Samoa	0.153	0.249	0.168	0.207	0.221	0.206	0.006	0.096	0.142	0.078
Papua New Guinea	0.170	0.276	0.190	0.231	0.250	0.229	0.007	0.107	0.189	0.125
Thailand	0.711	1.016	0.450	0.916	0.825	0.911	0.023	0.140	0.722	0.361
Mongolia	0.749	1.350	0.894	1.077	1.179	1.096	0.016	0.517	0.841	0.254
Burma	0.021	0.017	0.014	0.018	0.017	0.017	0.002	0.007	0.017	0.019
Australia	4.688	19.307	5.233	15.142	16.267	13.570	0.098	0.910	3.439	2.303
Viet Nam	0.323	0.283	0.246	0.264	0.264	0.264	0.036	0.128	0.398	0.210
Pakistan	0.107	0.011	0.100	0.035	0.019	0.034	0.085	0.044	0.155	0.116
Hong Kong Special Administrative Region (China)	2.421	3.734	2.478	3.037	3.293	3.098	0.097	1.413	2.876	0.976
Japan	2.399	1.222	1.631	1.558	1.630	1.725	3.890	0.768	3.115	3.521
India	0.481	0.553	0.525	0.503	0.548	0.502	0.104	0.326	0.519	0.299
Malaysia	1.703	1.786	1.176	1.569	1.730	1.557	0.079	0.980	2.176	0.849
French Polynesia	0.921	1.502	1.012	1.225	1.325	1.238	0.034	0.579	1.003	0.390
Vanuatu	0.098	0.159	0.107	0.129	0.140	0.131	0.004	0.061	0.114	0.037
Republic of Korea (South)	3.035	5.374	3.573	4.570	5.202	4.449	6.891	0.554	3.873	4.608
Macao Special Administrative Region	1.266	1.996	1.380	1.621	1.756	1.652	0.057	0.784	1.501	0.502

Countries	Climate change	Fresh-water eutrophi-cation	Marine eutrophi-cation	Fresh-water eco-toxicity	Human toxicity (cancer effects)	Human toxicity (non-cancer effects)	Ionising radiation (human health)	Respira-tory inor-ganics	Land use	Non-renew-able resource depletion
Tonga	0.185	0.302	0.203	0.244	0.265	0.248	0.007	0.116	0.216	0.071
Kiribati	0.097	0.159	0.107	0.128	0.139	0.131	0.004	0.061	0.113	0.037
Brunei Darussalam	3.181	0.718	1.168	1.062	0.864	1.132	0.519	0.462	4.896	2.327
Cook Islands	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
Singapore	2.688	0.333	1.512	0.741	0.468	0.752	0.452	0.564	4.148	1.955
Nauru	1.576	2.574	1.732	2.079	2.261	2.118	0.057	0.991	1.840	0.601
Guam	5.307	8.667	5.832	7.001	7.613	7.132	0.193	3.337	6.197	2.024
Cambodia	0.017	0.000	0.023	0.004	0.001	0.004	0.005	0.010	0.028	0.013
New Zealand	0.842	0.566	0.593	1.140	0.771	0.637	0.044	0.234	0.557	2.616
Lao People's Democratic Republic	0.033	0.050	0.036	0.052	0.049	0.043	0.002	0.021	-0.028	0.049
Maldives	0.372	0.607	0.409	0.491	0.533	0.500	0.014	0.234	0.434	0.142
Nepal	0.000	0.000	0.000	0.003	0.001	0.001	0.000	0.000	-0.015	0.008
New Caledonia	3.066	4.998	3.368	4.173	4.419	4.130	0.113	1.928	3.332	1.477
Bangladesh	0.082	0.022	0.036	0.031	0.025	0.032	0.014	0.015	0.125	0.060
American Samoa	1.330	2.173	1.462	1.755	1.908	1.788	0.048	0.837	1.554	0.508
Bhutan	0.045	0.019	0.043	0.258	0.129	0.051	0.009	0.026	-1.459	0.810
Central and South America										
Uruguay	-0.137	-0.203	-0.076	-0.062	-0.163	-0.193	-0.135	-0.118	-0.854	0.119
Falkland Islands (Malvinas)	1.212	0.577	0.969	0.635	0.570	0.654	0.227	0.459	1.835	0.825
Peru	0.154	-0.001	0.088	0.055	0.018	0.040	-0.002	0.068	0.177	0.141
Martinique	1.534	0.730	1.227	0.804	0.721	0.828	0.288	0.582	2.324	1.044
Ecuador	0.198	-0.013	0.231	0.050	0.005	0.033	0.050	0.093	0.232	0.198
Trinidad and Tobago	2.318	0.514	0.825	0.767	0.621	0.815	0.364	0.317	3.551	1.687
El Salvador	0.097	-0.031	0.157	0.031	0.005	0.001	0.017	0.051	0.122	0.287
Costa Rica	0.063	-0.013	0.104	0.125	0.039	0.019	0.009	0.033	-0.084	0.467
Bolivia	0.148	0.020	0.052	0.045	0.029	0.041	0.015	0.013	0.189	0.117
Cuba	0.539	0.003	0.623	0.124	0.033	0.118	0.159	0.268	0.907	0.433
Colombia	0.126	0.081	0.081	0.103	0.088	0.084	0.012	0.038	0.022	0.154
Montserrat	1.480	0.705	1.184	0.776	0.696	0.799	0.278	0.561	2.242	1.008
Jamaica	0.325	-0.018	0.436	0.078	0.002	0.059	0.103	0.186	0.549	0.290
Netherlands Antilles	1.983	0.949	1.587	1.249	0.957	1.098	0.372	0.753	3.043	1.724
Saint Lucia	0.848	0.404	0.678	0.444	0.399	0.458	0.159	0.321	1.284	0.577
Chile	0.833	1.355	1.443	1.164	1.304	1.029	-0.032	2.624	0.793	0.551
United States Virgin Islands	2.841	1.353	2.272	1.489	1.336	1.534	0.533	1.077	4.304	1.934
Bahamas	2.331	1.110	1.864	1.222	1.096	1.259	0.437	0.884	3.531	1.587
Haiti	0.012	0.000	0.016	0.003	0.001	0.003	0.004	0.007	0.019	0.011
Argentina	0.670	0.155	0.430	0.261	0.191	0.261	0.503	0.179	0.921	0.672
Antigua and Barbuda	0.476	0.227	0.381	0.250	0.224	0.257	0.089	0.181	0.721	0.324
Grenada	0.737	0.351	0.589	0.386	0.346	0.398	0.138	0.279	1.116	0.502
Dominican Republic	0.471	0.224	0.501	0.256	0.219	0.258	0.107	0.239	0.707	0.336

Countries	Climate change	Fresh-water eutrophi-cation	Marine eutrophi-cation	Fresh-water eco-toxicity	Human toxicity (cancer effects)	Human toxicity (non-cancer effects)	Ionising radiation (human health)	Respira-tory inor-ganics	Land use	Non-renew-able resource depletion
Saint Vincent and the Grenadines	0.440	0.210	0.352	0.235	0.209	0.238	0.083	0.167	0.639	0.314
Barbados	1.327	0.632	1.061	0.695	0.624	0.716	0.249	0.503	2.010	0.903
Venezuela (Bolivarian Republic of)	0.553	0.069	0.467	0.226	0.127	0.173	0.141	0.206	0.477	0.649
Nicaragua	0.128	-0.025	0.185	0.049	-0.007	0.012	0.032	0.070	0.205	0.200
Suriname	0.488	0.232	0.391	0.290	0.245	0.267	0.092	0.186	0.516	0.446
Guatemala	-0.049	-0.062	-0.005	-0.042	-0.065	-0.073	-0.077	-0.047	-0.204	-0.065
Honduras	0.169	0.005	0.224	0.050	0.016	0.041	0.051	0.098	0.229	0.160
Dominica	0.419	0.200	0.336	0.232	0.203	0.228	0.079	0.159	0.557	0.326
Cayman Islands	4.369	2.080	3.493	2.289	2.054	2.358	0.819	1.656	6.617	2.974
Brazil	0.152	0.127	0.028	0.181	0.095	0.093	0.114	0.040	-0.077	0.197
Puerto Rico	2.039	0.970	1.630	1.069	0.959	1.101	0.382	0.773	3.082	1.390
Saint Kitts and Nevis	0.983	0.468	0.786	0.515	0.462	0.531	0.184	0.373	1.489	0.669
Paraguay	0.034	0.014	0.033	0.197	0.098	0.039	0.007	0.020	-1.117	0.620
Belize	-0.414	-0.446	-0.311	-0.352	-0.436	-0.469	-0.325	-0.321	-1.104	-0.392
Guadeloupe	1.230	0.590	0.996	0.747	0.612	0.682	0.231	0.469	1.909	1.148
Guyana	0.368	0.175	0.294	0.193	0.173	0.199	0.069	0.139	0.557	0.250
French Guiana	0.098	0.029	0.082	0.111	0.061	0.044	0.002	0.029	-0.334	0.289
Panama	0.392	0.115	0.510	0.195	0.130	0.168	0.105	0.233	0.445	0.377
Eurasia										
Armenia	0.189	0.049	0.076	0.135	0.097	0.174	2.187	0.035	0.160	0.967
Tajikistan	0.042	0.011	0.020	0.061	0.034	0.022	0.007	0.010	-0.231	0.181
Kyrgyzstan	0.069	0.077	0.060	0.109	0.090	0.073	0.006	0.033	-0.189	0.178
Belarus	1.000	0.211	0.362	0.324	0.258	0.342	0.152	0.135	1.527	0.724
Latvia	0.540	0.105	0.187	0.215	0.148	0.182	0.072	0.064	0.584	0.521
Ukraine	1.186	1.167	1.562	1.135	1.269	1.327	4.858	0.430	1.361	2.454
Azerbaijan	0.593	0.133	0.225	0.204	0.163	0.211	0.098	0.090	0.874	0.455
Lithuania	0.398	0.056	0.166	0.180	0.084	0.121	0.050	0.052	0.583	0.411
Estonia	4.070	7.845	4.972	6.430	6.811	6.258	-0.264	2.762	4.080	1.396
Kazakhstan	2.148	3.774	2.439	3.027	3.307	3.073	0.045	1.413	2.365	0.784
Georgia	0.035	0.010	0.019	0.068	0.036	0.021	0.006	0.010	-0.296	0.204
Uzbekistan	0.485	0.172	0.212	0.214	0.187	0.217	0.074	0.093	0.678	0.365
Turkmenistan	1.197	0.273	0.425	0.401	0.328	0.428	0.193	0.167	1.839	0.874
Russian Federation & U.S.S.R.	2.112	3.255	1.826	2.860	2.799	2.872	3.812	1.576	2.411	2.481
Europe										
Hungary	0.763	2.478	0.550	2.348	1.989	2.385	3.513	0.141	0.716	1.784
Czech Republic	2.448	11.439	2.434	9.331	8.652	8.425	6.328	0.316	0.618	3.194
Gibraltar	2.209	1.948	1.765	1.762	1.792	1.809	0.261	0.917	3.045	1.263
Serbia	1.900	13.546	2.327	11.484	10.205	11.582	0.099	2.133	0.345	0.712
Cyprus	1.634	0.000	2.142	0.429	0.095	0.373	0.557	0.953	2.844	1.444
Denmark	0.783	0.698	0.376	1.602	0.800	0.582	0.028	-0.015	0.141	1.256

Countries	Climate change	Fresh-water eutrophi-cation	Marine eutrophi-cation	Fresh-water eco-toxicity	Human toxicity (cancer effects)	Human toxicity (non-cancer effects)	Ionising radiation (human health)	Respira-tory inor-ganics	Land use	Non-renew-able resource depletion
Bosnia and Herzegovina	1.264	3.522	1.505	3.089	2.914	3.136	0.064	0.912	0.927	0.704
Italy	1.088	0.469	0.777	0.680	0.557	0.486	0.194	0.276	1.904	1.523
France	0.242	0.108	0.221	0.641	0.414	1.003	15.289	0.109	0.394	6.870
Poland	1.715	5.359	1.525	4.229	4.248	4.395	0.045	0.539	0.885	0.704
Sweden	-0.063	-0.031	0.102	0.796	0.265	0.610	18.878	-0.126	-1.303	6.590
Norway	0.272	0.058	0.185	1.145	0.336	0.210	0.029	0.081	-0.433	2.477
Portugal	0.711	0.336	0.621	0.787	0.431	0.400	0.044	0.259	0.777	1.765
Romania	0.675	3.839	0.648	2.971	2.863	2.976	1.275	0.223	0.207	0.774
Belgium	0.591	0.045	0.326	0.733	0.271	0.667	9.496	0.015	0.018	4.137
Slovakia	0.592	1.516	0.570	1.519	1.312	1.617	6.011	0.513	0.529	2.593
Germany	1.620	5.805	0.910	4.718	4.514	3.863	2.790	0.052	0.643	2.632
Greece	1.995	13.937	1.970	12.307	10.542	11.724	0.309	0.912	1.411	1.315
Luxembourg	1.607	-0.431	0.573	-0.041	-0.241	-0.098	-0.214	0.197	1.542	0.369
Netherlands	1.427	0.142	0.551	0.429	0.336	0.308	0.450	-0.013	0.272	0.781
Faeroe Islands	1.278	0.022	1.666	0.507	0.125	0.328	0.440	0.748	1.990	1.478
Iceland	0.618	0.440	1.422	2.432	2.384	0.900	0.141	0.411	-2.627	14.701
Croatia	0.428	0.285	0.384	0.369	0.325	0.294	0.028	0.146	0.479	0.433
Austria	0.663	0.204	0.258	0.448	0.339	0.206	0.226	0.018	0.392	0.800
Turkey	0.811	2.211	0.714	1.866	1.720	1.782	0.024	2.045	0.510	0.468
Montenegro	1.407	2.608	1.669	2.186	2.329	2.122	0.016	0.975	0.811	0.837
Switzerland	0.016	0.047	0.073	0.323	0.200	0.441	9.649	0.030	-0.161	3.012
Ireland	1.432	0.680	0.827	2.012	0.794	0.887	0.054	0.269	0.810	1.679
United Kingdom	1.269	0.899	0.877	1.056	0.994	1.019	2.444	0.284	0.830	1.769
Slovenia	1.395	7.403	1.907	6.451	5.719	6.503	7.149	1.343	0.372	3.226
Bulgaria	1.906	9.658	2.020	7.953	7.401	7.715	5.435	0.727	0.894	3.355
Finland	1.067	0.912	0.580	1.191	1.023	0.933	10.630	-0.024	-0.037	3.510
Albania	0.005	0.002	0.005	0.031	0.016	0.006	0.001	0.003	-0.178	0.099
Spain	1.007	0.546	1.074	1.197	0.741	0.835	3.168	0.365	2.750	4.471
Middle East										
Qatar	5.760	1.316	2.047	1.931	1.580	2.059	0.927	0.805	8.851	4.207
Iraq	0.516	0.095	0.286	0.167	0.122	0.172	0.103	0.120	0.786	0.402
Saudi Arabia	3.477	0.139	2.245	0.885	0.367	1.037	0.463	1.038	5.482	2.334
Lebanon	1.570	0.017	2.049	0.375	0.105	0.367	0.542	0.918	2.695	1.313
United Arab Emirates	6.598	1.478	2.479	2.207	1.781	2.345	1.088	0.985	10.173	4.835
Kuwait	8.207	0.672	8.166	2.197	1.095	2.248	2.341	3.608	13.737	6.516
Israel	3.355	4.538	3.342	3.814	4.033	3.864	0.225	1.854	4.200	1.524
Iran (Islamic Republic of)	1.119	0.038	0.914	0.284	0.113	0.333	0.215	0.429	1.938	0.833
Oman	2.336	0.423	1.312	0.732	0.534	0.772	0.469	0.552	3.692	1.754
Bahrain	3.670	0.839	1.304	1.230	1.006	1.312	0.590	0.513	5.639	2.680
Yemen	0.136	0.007	0.154	0.034	0.014	0.035	0.042	0.069	0.232	0.110
Jordan	0.863	0.052	0.940	0.223	0.097	0.226	0.262	0.417	1.460	0.694

Countries	Climate change	Fresh-water eutrophi-cation	Marine eutrophi-cation	Fresh-water eco-toxicity	Human toxicity (cancer effects)	Human toxicity (non-cancer effects)	Ionising radiation (human health)	Respira-tory inor-ganics	Land use	Non-renew-able resource depletion
Syrian Arab Republic	0.708	0.087	0.581	0.206	0.123	0.211	0.178	0.253	1.138	0.561
North America										
United States of America	4.224	4.555	3.238	4.891	5.278	4.604	7.327	1.356	3.862	5.777
Saint Pierre and Miquelon	3.860	5.503	3.767	4.529	4.877	4.624	0.203	2.123	4.711	1.670
Canada	1.626	2.154	1.344	2.870	2.330	2.483	6.349	0.708	-0.206	4.828
Greenland	2.365	3.372	2.308	2.775	2.989	2.833	0.125	1.301	2.887	1.023
Bermuda	4.436	6.324	4.329	5.204	5.605	5.314	0.234	2.440	5.414	1.919
Mexico	0.681	0.420	0.620	0.464	0.440	0.454	0.370	0.293	1.000	0.602

[a] Normalised scores are obtained by dividing the per-capita impact score obtained for a given country and impact category by the global per-capita impact score. Normalised scores above 1 are marked in grey.

[b] Countries in *Italic* are countries, for which results should be considered with caution due to large uncertainties. They are associated with extrapolations in both electricity generation data and life cycle inventories (see Section 2.4 in manuscript).

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