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Indicators of the impacts of development on environment: A comparison of Africa and Europe

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ABSTRACT

We calculate and present quantitative data over the impact on the environment for a group of Western European countries and a group of Western African countries. Six major issues are considered: (1) land use, (2) modification of atmospheric composition, (3) diminution of water resources, (4) alteration of nitrogen cycle, (5) loss of biodiversity, and (6) threat of fisheries. We show the high sensibility of the results to the choice of indicators. Then we show that the impacts in African countries are relatively higher than in European countries, in comparison with their respective economic levels. We conclude with several interpretations of these results pleading for an increased consideration of sustainable development objectives in Africa.

1. Introduction

It is commonly admitted that the "North" consumes much more natural resources and causes much more damage to the global environment than the "South". This is not only a global injustice as regards the use of some common resources but also a central concern in the perspective of sustainable development, which is still unsolved up to now. The production and consumption patterns in the North and in the South have long and often been analysed from that point of view. So, according to G.H. Brundtland "If 7 billion people were to consume as much as in western countries ten worlds instead of one would be necessary to meet our needs" (Hille, 1997) while according to W. Sachs, at the current pace, "five or six planets" would be necessary (Sachs, 1993). This order of magnitude can be found back in the European texts claiming since the 1990s that a factor 10 reduction of energy use will be required.

To analyse these data in details, scientific and official reports based on indicators appear to be particularly interesting sources. Indeed, in the context of international comparability and even competition that characterizes the present-day globalization, the classification of countries on the basis of quantitative indicators has become widely spread. Setting the environmental benchmarking tool aside, these comparisons may have impacts on the international negotiations on environment or on the integration of environmental criteria in the cooperation policies. The validation or invalidation of the development theories in a perspective of sustainability is also at stake when comparing environmental and economic indicators.

This underlying issue of compatibility of environment and economic development – a key issue in sustainable development – is illustrated, for example, by the differences in message between the reports produced according to the Environmental Sustainability Index for the World Economic Forum (WEF, 2002, 2004; Jah and Murthy, 2003) and the ecological footprint calculated by Global Footprint Network (WWF, 2004, 2006, 2008). Both are well-documented but reach opposite conclusions according to the chosen environmental indicators. The first report tends to demonstrate the compatibility of economic and human development with environment protection while the second focuses on overconsumption of the natural resources by the economically rich countries. See also the controversy, based on indicators, between Lomborg on the compatibility between economic development and environment, and Brown's relatively alarmist analyses contained in the annual State of the World report (Zaccaï et al., 2003).

With respect to the above challenges, the initial goal of this contribution is to test the utility and practicability of indicators to compare the environmental challenges in an economically developed region in the North and another less developed region in the South. For each issue, we present a series of indicators used to eval-

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uate its various aspects. This approach differs from that of reports which generally consider a few, or even only one, indicator(s). This contribution will document how considering only one indicator by issue can lead to important biases in comparisons and analyses. A secondary objective is, on the basis of the empirical data that have been collected and analysed, to address the question of human development on various major environmental issues in order to nourish the key debate on sustainable development in Africa.

2. Methodology

In order to limit controversies about the choice of analysed topics, we concentrated on environmental issues that are recognized in the scientific literature as being global and for which the extent of the total impact of man on nature is considered to be most important. To do so, we based our work on a reference publication, the paper of Vitousek et al. (1997b) (obviously, other configurations are also possible, see for example (UNEP, 2002; Millennium Ecosystem Assessment, 2005)). These authors characterize six major global-scale environmental issues (*global-scale indicator of change*): (1) land use by man, (2) modification of atmospheric composition, (3) diminution of water resources, (4) alteration of the nitrogen cycle, (5) loss of biodiversity, and (6) fisheries depletion. For each of these global problems, we examined, on the one hand, the relative contribution of each country to the global pressures on environment and, on the other hand, some impacts felt more locally by the same countries. With this choice, we try to consider the environmental issues from the global point of view (which is important for an issue of a world-wide extension of Western patterns) as well as according to their local impacts (directly involved in the development of a country).

The chosen countries belong to two geographically and economically distinct groups:

- Five West-European countries: Belgium, France, the Netherlands, United Kingdom and Switzerland.
- Five West-African countries: Benin, Burkina Faso, Ivory Coast, Guinea-Bissau and Senegal.

Both groups have an equivalent surface and present some geographical and socio-economic diversity within a common regional area, for Europe and Africa, respectively (see supra, Table 1). For the sake of simplicity these groups are called Europe and Africa (unless otherwise stated), which does not mean that the whole continents are considered. The timeliness of the data is not essential for our purpose. However, it would be interesting to repeat this exercise on a 10-year interval for assessing global evolutions.

3. Results per issue

3.1. Land use by man

The relationship of a society with its living area depends on a multitude of social, economic and environmental factors. Vitousek et al. (1997b) consider the transformation of territory as one of the major disturbances, admitting that this topic includes various activities which may have very different intensities and impacts.

The contribution of each country to the pressure on world lands can be illustrated by the ecological footprint expressed in global hectares (gha) equivalent to the average global productivity per capita. The main advantage of this indicator is that it includes the impacts of consumption of residents of one country to bioproductive surfaces abroad. It shows the relative responsibility for global land change rather than national impact. According to a particular methodology (Wackernagel et al., 2000), this footprint aggregates a series of impacts, including land use which is also used in other indicators of ours. Moreover, as this concept is based on the use of renewable resources only, the energy consumptions are included in production equivalents of biomass. However, note the relative importance of energy consumption: more than 50% for all European countries. This footprint is thus far from being an «area» in the strict sense of the word. We would say – it is competition for ecological services –which are competing for bioproductive space, so sequestration service is competing with providing crops or timber.

The semi-natural territory indicator, as proposed by Prescott-Allen (Prescott-Allen, 2001) under the name "modified territory", corresponds to the territory that has been moderately or strongly influenced by man except by cultivation and the built-up area's. Therefore, pasture lands are also included.

The "built-up territory" is the territory occupied by buildings, transport infrastructures and other human structures, including mines and quarries, dumping sites, parks and gardens. It is the qualitatively most perturbed land. The «cultivated territory» is the area submitted to modifications, a.o. through ploughing.

The urbanization rate (built-up territory) is four times higher in Europe and the occupation rate of cultivated land is twice higher. On the other hand, according to Prescott-Allen's calculations (Prescott-Allen, 2001), the semi-natural territory appears to be equivalent in both African and European groups. This concept includes partly artificialized pasture lands, but in a different way depending on they are enclosed (in the North) or not (in the South). "Natural" areas, i.e. nearly untouched areas constitute the remaining part of the land use. They are practically nonexistent in Western Europe and the ratio between Africa and Europe amounts to 1–100 (Table 2).

Beyond these orders of magnitude, to determine the impact on environment, it would be necessary to measure much more precisely the consequences of the various types of land use changes and how they are related to various crucial factors. Table 2 highlights that the differential of global responsibility[1] (ecological footprint) is higher than the differential of impact in both reference regions. The calculation of the ecological footprint, which includes "imported" environment, partly explains this difference. Africa appears to be the only one still having a reserve of pure "natural area" which could, because of its rarefaction, become a reason for conflicts between world "developers" and "protectors". This space could be one of the challenges of the economic globalization. Privatization is indeed likely to question the principle of "nourishing earth" that characterizes the African traditional land system (land belongs to the farmers only for the time they need it for their cultivations, a principle that prevents from any differed exploitation).

3.2. Modification of the atmospheric composition

The main atmospheric disturbers emitted by man and having consequences on the climate are the greenhouse gases (GHG) including CO_2 which is the most important of them.

Africa as a whole only accounts for 3.5% of the global CO_2 emissions and these emissions mostly come from North Africa and South Africa (Marland et al., 2001). On the other hand, Africa is the most vulnerable continent to climate variability and the Intergovernmental Panel on Climate Change (IPCC) expects an increase in the intensity of droughts and floods associated with the El Niño phenomenon. This will adversely affect food security, since poverty reduces the adaptive capacity (GIEC, 2001). The coasts of the Gulf of Guinea where one third of the population concentrates on a coastal fringe of 60 km (UNDP, 2003), would be, for example, threatened by the sea-level rise, particularly in Senegal, Gambia and Guinea-

[1] Indicators of "responsibility" are shadowed in grey in the tables. Others are "state" or "impact" indicators.

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Table 1
Socio-economic data of the considered countries.

Country	Population (millions)	Rural pop. (millions)	Surface (millions)	Biocapacity (millions)	GDP/inhab. (USD/inhab.)	Human wellbeing index[a]
Source	FAO (2004a,b)	FAO (2004a,b)	UNDP (2003)	Wackernagel et al. (2000)	UNDP (2003)	Prescott-Allen (2001)
Date of the datum	2000	2000	2000	1996	2001	2000
Belgium	10	0.3	3	23	22 323	80
France	59	14.5	55	249	22 129	75
The Netherlands	16	1.7	4	37	23 701	78
Switzerland	7	2.3	4	17	34 171	78
United Kingdom	60	6.4	24	107	24 219	73
Average European group	30	5	18	87	23 599	75
Benin	6	3.6	11	8	368	27
Burkina Faso	12	9.4	27	8	215	17
Ivory Coast	16	8.6	32	28	634	20
Guinea-Bissau	1	0.9	4	3	162	13
Senegal	9	5.0	20	8	476	20
Average African group	9	5	19	11	452	20
Ratio Egr/Agr	3	1	1	8	52	4

Source: authors.
[a] Definition of the human wellbeing index proposed by Prescott-Allen (2001, p. 13): Average of the health and population, wealth, knowledge, community and equity indexes or average of the health and population, wealth, knowledge, community and equity indexes, the lowest of them.

Bissau (GIEC, 2001). For example, at low tide the land surface of this last country is larger by one quarter than at high tide, with brackish water coming up to 100 km into the country.

It appears that if the European countries under revision, particularly The Netherlands, may also fear the effects of global warming, they seem to bear a greater responsibility in this phenomenon, as they are emitting six times more GHG per inhabitant than their African counterparts (see supra, Table 3), and this without taking their historical responsibility into account (accumulation of emissions in the atmosphere). This order of magnitude is much higher than the reduction commitment of the European countries in phase one of the Kyoto Protocol (reducing emissions by 7% between 1990 and 2010). If energy-related CO_2 emissions are used as a proxy for GHG emissions, the ratio reaches 19. This example illustrates how sensitive it can be to test countries against the proposed indicators.

Now how can we estimate the perturbation of a “national” GHG cycle? Due to the even distribution of GHG shift of concentration on world atmosphere, we can make the hypothesis that the direct perturbation of the GHG natural cycles is evenly distributed. Following IPCC (2007), the carbon concentration in atmosphere is around 380 ppm as compared to a “natural” concentration of 280 ppm in the preindustrial time, which makes a resulting 100 ppm of perturbation, or 100/280 = 36%. The resulting ratio of perturbation between the North and the South would around 1 (even if the literature suggest that the final impacts would be unevenly distributed).

Table 3 confirms that the North bears a higher responsibility for atmosphere change than the South, but in varying orders of magnitude according to the comparison bases. In this particularly investigated problem of climate change, the way the variations are calculated has a direct impact on the criteria according to which international justice and its future are approached.

3.3. Disturbances of the water cycle

At the global level, mankind utilizes more than half of the accessible fresh water, 70% of it being used for agriculture (Postel et al., 1996). The human disturbances of the natural hydrological cycle are various: not only as a result of the direct use of water in various processes, such as agriculture or electricity production, but also as a consequence of the canalization of water courses, drainage of wetlands or waterproofing of permeable surfaces (urbanization). Many cases of rupture appear at various levels, generating local problems, like floods or droughts, conflicts, health hazards, but also global problems due to changes in evapotranspiration, decrease in the flow of the greatest rivers, and even the modification of the major inland water stretches (Lake Tchad for example), generating economic, health and climatic problems (Kotlyakov, 1991; Milly and Dunne, 1994).

Table 2
Territory disturbance.

	Ecological footprint (gha/inhab.)	Semi-natural territory (%)	Built-up territory (%)	Cultivated territory (%)	Natural territory (%)
Source	Wackernagel et al. (2000)	Prescott-Allen (2001)	Prescott-Allen (2001)	Prescott-Allen (2001)	Prescott-Allen (2001)
Date of the datum	1996	2000	2000	2000	2000
Belgium	6.08	42	17.7	40.3	0.0
France	7.30	55.1	5.4	39.3	0.2
The Netherlands	5.98	49.9	16.5	33.5	0.0
Switzerland	6.60	78.4	7.1	14.1	0.4
United Kingdom	6.26	51	12.1	36.9	0.0
Average European group	6.64	54	8.0	33	0.1
Benin	0.97	69.6	2.5	14.9	13
Burkina Faso	0.90	71.2	2	14.8	12
Ivory Coast	0.95	49.4	2.2	27.4	21
Guinea-Bissau	0.80	84.4	2	12.8	0.8
Senegal	1.06	81.5	2.2	15.3	1
Average African group	0.96	65	2.1	17	10
Ratio Egr/Agr	7	1	4	2	1/100

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Table 3
Atmosphere disturbance.

	Energetic CO_2 emissions per inhab.(Kg en. CO_2/inhab.)	GHG* emissions per inhab. (kg en. CO_2/inhab.)
Source	Prescott-Allen (2001)	Calculated
Date of the datum	2000	2000
Belgium	10 065	14 333
France	5 749	8 699
The Netherlands	10 401	13 648
Switzerland	5 678	7 235
United Kingdom	8 694	11 073
Average European group	7 676	10 456
Benin	119	1 573
Burkina Faso	87	2 218
Ivory Coast	820	1 064
Guinea-Bissau	188	3 705
Senegal	329	2 306
Average African group	410	1 770
Ratio Egr/Agr	19	6

* CO_2, CH_4, N_2O, PFCs, HFCs, SF_6, without changes in land use (data (WRI, 2005)), to which CO_2 emissions from the slash-and-burn method have been added (1995 data from Olivier (2002)).

The water uses follow one another during the cycle, with possible successive re-uses and the consequent modification of the water quality. The cooling of power stations is an example of uses which are very widespread in Belgium and in France and doesn't prevent a future re-use but breaks the cycle quantitatively (evaporation) and qualitatively (thermal pollution). As the successive uses are added, like for most of the international data bases (EEA, 2003; WRI, 2003), the index of "water disturbance", usually calculated by the simple arithmetic sum of the disturbances divided by the resources, could exceed 100%. To avoid this bias, we propose to use a multiplicative model: percentages of disturbance can only be applied to water that has not been disturbed yet (see the g formula in the note of Table 4).

The available water quantity (Table 4, variable *a*) is on average three times higher in the European group than in the African group even if there are huge international variations (from 46 mm in Burkina Faso to 2191 mm in the Netherlands), without mentioning the local variations which are a critical factor for some arid zones in Africa. On average, the renewable groundwater resources (variable *b*) are two times higher in the European group.

In the Northern countries, the domestic uses per unit of area are on average 23 times higher while the cumulative industrial uses are nearly 264 times higher (Table 4, variables *c* and *d*). The agricultural use of water is twice higher in the North, because of the determinant weight of the Netherlands (where «agricultural water» mainly represents drainage), and France. Without these countries, the ratio would be reverse.

Agriculture and urbanization are the main factors modifying the streaming conditions of the collected rainwater. Moreover, they are often accompanied by works directly modifying the flow. Change in the erosion and sedimentation conditions gives then rise to modifications in series of the water cycle. The permanent crops, the grasslands and the forests, by maintaining a permanent soil cover, play, by first approximation, a less determining role in these phenomena. The results (Table 4, variable *f*) suggest that the transformation of land cover by urbanization or agriculture is responsible for eight times more rainwater collection disturbance in Europe than in Africa.

When we bring these figures into proportion of the total available water resources including apparent reuse (Table 4, variable *g*), it appears that, on average, the water cycle undergoes three times more disturbances in the European countries than in the group of African countries.

The method of calculation of any national and annual indicator of this type hides the subjacent problems related to, for example, the seasonal variation of the resources and uses (increased pressure on the resources during the dry season in Africa) and the difficulty for the environment, as well as for man, to have water of sufficient quality at the appropriate place and period. The rate of groundwater use, particularly in the dry season in the sub-Saharan regions, should be specified as these groundwater resources probably undergo the highest pressure. The same situation prevails, *mutadis mutandis*, in some regions of Europe.

These orders of magnitude, lower than the aggregated indicators, suggest that the kind of use is of crucial importance. Currently, with equivalent ratios of use, the problems related to water are more serious in West Africa than in Western Europe, and this for both health and environment. A rapid increase in consumption (and a decrease in the reserves) in a very agrarian society,

Table 4
Disturbance in the water cycle.

	Total renewable water resources (mm eq./year)	Groundwater resources (mm eq./year)	Domestic use of water (mm eq./year)	Industrial use of water (mm eq./year)	Domestic use of water (mm eq./year)	Disturbances according to arable and urban areas (mm. eq;/year)	Water disturbance (%)
Source	FAO (2004a,b)	FAO (2004a,b)	FAO (2004a,b)	FAO (2004a,b)	FAO (2004a,b)	Calculated	Modelled
Variables	*a*	*b*	*c*	*d*[a]	*e*	*f*[b]	*g*[c]
Date of the datum	1961–1990	2000	2000	2000	2000	2000	2000
Belgium	599	29	23.7	219	1	275	67
France	369	181	11.4	54	7	143	50
The Netherlands	2 191	108	11.7	115	65	776	41
Switzerland	1 296	61	15.1	46	1	218	21
United Kingdom	605	40	8.5	30	1	219	40
Average European group	566	130	11.2	55	8	195	43
Benin	220	16	0.3	0.24	2	43	21
Burkina Faso	46	35	0.3	0.01	3	7	21
Ivory Coast	251	117	0.7	0.34	2	28	12
Guinea-Bissau	858	388	0.3	0.02	3	85	10
Senegal	200	39	0.5	0.30	7	28	18
Average African group	200	75	0.5	0.21	3	26	15
Ratio Egr/Agr	3	2	23	264	2	8	3

[a] Including water used for cooling.
[b] Share of the arable and urban areas in the total available resources. The unit (mm equivalent/year) represents the volume of water per unit of total surface (100 l/ha), or the average water level in each point.
[c] $g = 1-(1-c/a)\times(1-d/a)\times(1-e/a)\times(1-f/a)$.

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having limited or no depollution equipment, may cause acute problems. A new indicator of "water stress", considering the local potential disturbance, should be developed: it is indeed possible that, beyond a certain level of disturbance, a phenomenon of irreversibility (dryness, floods, etc.) appears in a given context. A country, or rather a region should then never exceed this threshold of good management, the basis of any development project should be recycling and re-use cycles without additional natural disturbance. Nevertheless, in light of the figures that we present, it seems that some West African regions still have a "potential of sustainable water disturbance" that is unexploited for human development.

In Africa, water pollution becomes increasingly worrying as it limits the access to salubrious water (UNDP, 2003), which is a major factor of diseases and mortality. The quantitative indicator of use of resources, provided it is calculated on a sufficiently small temporal and geographical scale, can provide suspicion on potential problems related to water. It is often when it becomes rare or overexploited or when its natural flow has been disturbed that water causes health problems, floods, dryness, etc.

3.4. Alteration of the nitrogen cycle

Nowadays, human activities enrich ecosystems with at least as much assimilable nitrogen[2] (approximately 140 million tonnes per year) as all combined natural sources (Galloway et al., 1995; Vitousek et al., 1997a). The production of fertilizers, the growing of nitrogen-fixing plants or the combustion in the presence of atmospheric nitrogen contribute to these processes on the continents. Even if the terrestrial ecosystems denitrify about 120 million tonnes of nitrogen every year, they become increasingly rich in nitrogen (Duvigneaud, 1980). The oceans which denitrify about 25–99 million ton every year (Ibid.) cannot compensate the global assimilable nitrogen enrichment. The consequences of the enrichment of the biogeochemical cycle influence, inter alia, the greenhouse effect, the "acid rains", the eutrophication of rivers, the visibility reduction (winter smog), the increase in the concentration of ozone or suspended particles in the air (Galloway et al., 1995; Vitousek et al., 1997b; Galloway, 2001; Galy-Lacaux et al., 2003). This enrichment also contributes to the nitrogen pollution of ground water which is often the main source of water for human consumption. These phenomena are particularly pronounced in Europe where no sign of major improvement is to be perceived (EEA, 2003). Finally, the estuaries are also being polluted by an excess of nutrients, with major impacts on the biodiversity and the viability of the fishing activities (Hallegraeff, 1993; Nixon et al., 1996; UNEP, 2002).

Emissions of nitrogen oxide (NO_x) and of ammonia (NH_3) – compounds that contribute more than half of the world anthropic contribution – decrease very slowly in Western Europe. Among the 140 million tonnes of nitrogen (NR) annually added to the cycle, 34 are added in the form of NO_x and 43 in the form of NH_3 (Galy-Lacaux et al., 2003). In West Africa, the phenomenon has been little studied but the importance of the burning of biomass (slash and burn method) and the changes in land use should not be neglected (Galy-Lacaux et al., 2003; Lacaux and Sigha, 2003).

At country level, nitrogen is artificially brought into the ecosystems by the spreading of nitrogenous mineral fertilizers, the burning and the cultivation of leguminous plants. This direct input in the ecosystem should be added to the balance of net (positive or negative) commercial imports of nitrogen as proteins.

This last type of nitrogen, consumed by animals and humans finally add further to the nitrogen inputs in the ecosystems through manure spreading and the sewers.

Table 5 shows an estimate of the quantity of nitrogen brought by the human activities into the biogeochemical cycle of each selected country, expressed in kg of nitrogen (N) per unit of national area. The selected flows correspond to the main standard items of the nutriment balance methodology promoted by OECD and Eurostat (see Gybels et al., 2009).

The consumption of mineral fertilizers introduces in the cycle 50 times more nitrogen per ha in Europe than in Africa every year and this ratio increases up to 67 for burning. The share of nitrogen fixed by the cultivation of leguminous plants is negligible, just like the net quantity of imported food nitrogen (except for the Netherlands which account for a net export of nearly 11 tonnes per year and per ha).

This assessment enables us to estimate roughly the anthropic nitrogen input per hectare in each country. In total, while the African countries have an average input of about 2 kg per ha/year, the European countries are confronted with an enrichment that is 26 times higher.

We still have to assess which proportion of the natural nitrogen fixation in each country this input represents. To a first approximation, we consider that the biogeochemical cycle is proportional to the primary productivity of the considered ecosystems and thus to the biocapacity (of the world productivity equivalent) calculated by Wackernagel et al. (2000). The ratio between artificial input of nitrogen and biocapacity in ha is thus related to the disturbance of the natural cycle. This indicator appears in the last column and presents a ratio of 3–1 in the European group.

We calculated (not in the table) that the responsibility of each country for this problem amounts to 36 kg of fixed nitrogen per capita in the North for 5 kg in the South, or a ratio of 7. Once again, the responsibility of the North is higher than the impacts felt.

3.5. Loss of biodiversity

The changes in land use, the resources needs, deposits of nutrients and pollutants, cultivation and pasturage, breaking up and impoverishment of the habitats and the spreading of invasive species represent major constraints to the maintenance of the biodiversity of ecosystems. These evolutions which are directly attributable to human activities lead to important changes in the species distribution in the world.

It should be noticed that the maintenance of biodiversity is one of the ecological problems for which the options and priorities can strongly vary with the actors and the situations. For example, the local socio-economic usefulness of protecting natural species can strongly differ from the value set on maintaining biodiversity, particularly at international level.

Wackernagel et al. (2000) evaluate the responsibility for the loss of biodiversity as a percentage of the ecological footprint. The Europe/Africa ratio amounts to 7–1, just like the ecological footprint for "land" as shown in Table 2. We are just pointing out the competition for biocapacity, regardless of its local quality or biodiversity, only because we did not find a better available proxy at national scale. Future biodiversity indices are proposed by Lamba et al. (2009) and Rezaa and Abdullaha (2011).

The average percentage of threatened indigenous species (birds and mammals), promoted by OECD (2008), is three times higher in the Northern group than in the Southern group (see supra, Table 6). This illustrates the higher relative pressure on the indigenous biodiversity in the North. One should keep in mind that these relative indicators do not integrate the differences in biological richness of the various countries. In absolute figures, there are twice as many

[2] Contrary to atmospheric nitrogen N_2 that can be considered as inert.

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Table 5
Disturbance of the nitrogen cycle.

Source	Consumption of mineral fertilizers (kg N/ha/year)	Burning (kg N/ha/year)	Cultivation of leguminous plants (kg N/ha/year)	Net import of N from food (kg N/ha/year) [b]	Anthropic input of nitrogen (kg N/ha/year)	Anthropic input of nitrogen by biocapacity (kg N/ha eq./year)
Source	FAO (2004a,b)	EMEP (2003) and estimates[a]	Eurostat (2004) and estimates	Calculated	Calculated	Calculated
Date of the datum	2000	2000	1997	1996	2000	2000
Belgium	48.9	26.1	1	−0.1	76	10
France	42.0	6.9	3	2.4	54	11
The Netherlands	72.2	27.7	1	−11.3	89	11
Switzerland	11.7	5.9	1	0.5	19	5
United Kingdom	45.9	19.9	2	4.5	72	15
Average European group	43.3	11.9	2	2.16	60	12
Benin	1.3	0.1	1	−0.1	3	4
Burkina Faso	0.4	0.0	1	0.0	1	5
Ivory Coast	1.2	0.4	2	0.1	3	4
Guinea-Bissau	0.3	0.1	1	0.0	1	1
Senegal	0.8	0.1	1	−0.2	2	5
Average African group	0.9	0.2	1	−0.03	2	4
Ratio Egr/Agr	50	67	2	−63	26	3

[a] Southern group estimated from its CO_2 emissions and the ratio between oxidized nitrogen and the CO_2 from the European group.
[b] Estimated from the composition in proteins (FAO, 1949; Ramseyer, 2002) and thus in nitrogen (FAO and WHO, 1973) of the foodstuffs and from the statistics of international trade of the FAO (Wackernagel et al., 2000). A negative figure means an export balance, *e*: anthropic input of nitrogen = *a* + *b* + *c* + *d*.

species of mammals and birds in the Southern countries. The ratio N/S would be 1.5 in absolute terms.

The last column of the table is an estimate of the share of biological productivity that is “domesticated” for man use. It is the ratio between the ecological footprint of production (Wackernagel et al., 2000) and the biocapacity (Wackernagel et al., 2000). The ecological footprint of production represents the use by a country of its biocapacity in km^2 (of global productivity equivalent) per capita. The biocapacity is the ecological production capacity, expressed here in global equivalent km^2/capita. This calculation suggest that, in the considered African countries, the level of domestication of the ecological productivity is already high: according to this “proxy” indicator and within the statistical approximations, the ecosystems of the European group would only be 1.5 times more domesticated than the African ecosystems.

3.6. *Exhaustion of the fisheries*

The proportion of world fish stocks that are exhausted, overexploited or rebuilding is increasing and amounts to nearly 25% (FAO, 2004a,b).

In order to address the pressures on fisheries, we have chosen indicators that deal with consumption on the one hand, and with the catches of the considered countries on the other hand. It is important to note that there are significant variations within the two groups.

The total ecological footprint of the African fish consumption – fresh fish or derived products – (ha/inh.) is three times smaller than that of the European countries, except Senegal which has an equivalent footprint (see Table 7).

The factors that are important to give an overall picture of the situation are: the availability of fish, the fishery products, the local spending patterns and finally the level of preparation of fish before its marketing.

The countries having the greatest apparent consumption (before transformation) are Senegal and The Netherlands. Senegal is also among the highest scores as regards fleet capacity (in tonnes) per km^2 of fishing area (including fresh water), just after Belgium. This last indicator is related to the capacity of these countries to fish in the well-stocked national, foreign and international waters. Conversely, Guinea-Bissau, which has well-stocked coasts but also one of the smallest fishing capacity, has its resources exploited by big European, Korean and Russian trawlers which are not very concerned about preserving the environment. Shrimp breeding which already caused the destruction of about 50% of the mangroves in the world, constitutes an additional danger (Kestemont and Le Menach, 1992; Martinez-Alier, 2002; UNEP, 2002).

Burke et al. (2001) use the ratio between the value of the output in 2001 and the maximum value of the output recorded between 1950 and 2004 (fourth column of Table 7). It represents an estimate of the maximum output potential, i.e. the biocapacity of the fishing areas covered by each country. The observed deficits give an idea of the decrease in productivity and thus the loss of biomass of the exploited fisheries. This indicator reveals that the pressure on the fishing areas of West Africa (−14%) and on those of Western Europe (−16%) is equivalent.

The last indicator (right column) is the ratio of sea catches in territorial waters with the “sea capacity” calculated as the equivalent fishing area of the average world productivity. This indicator

Table 6
Disturbance of the biodiversity.

Source	Average share of threatened mammal and bird species (%)	Domestication of the ecological productivity (%)
Source	Prescott-Allen (2001)	calculated from Wackernagel et al. (2000)
Date of the datum	2000	1996
Belgium	9.8	98
France	10.1	92
The Netherlands	10.3	96
Switzerland	4.3	94
United Kingdom	12.2	99
Average European group	9.4	94
Benin	1.9	58
Burkina Faso	2.5	100
Ivory Coast	4.6	58
Guinea-Bissau	0.9	30
Senegal	3.8	75
Average African group	3.1	65
Ratio Egr/Agr	3	1.5

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Table 7
Disturbance on fisheries.

Source	Ecological footprint of fish consumption (ha/inhab.) Wackernagel et al. (2000)	Consumption of sea fish (kg/inhab.) FAO (2004a,b)	Fleet capacity (Tcap/km²) Prescott-Allen (2001)	Production shortfall of sea fish (% of fall) FAO (2004a,b)	Ratio between territorial sea catches/km² * and sea capacity (T/km² eq.) Wackernagel et al. (2000) and FAO (2004a,b)
Date of the datum	1996	2001	1995	1950–2001	2001
Belgium	0.056	3	7.75	−60	510
France	0.089	10	1.02	−5	7
The Netherlands	0.082	34	2.78	−13	286
Switzerland	0.055	1	0.9	−41	
United Kingdom	0.055	6	0.46	−24	16
Average European group	0.071	10	2.58	−16	15
Benin	0.011	2	1.40	−13	20
Burkina Faso	0.001	1	nc	0	–
Ivory Coast	0.035	9	0.26	−28	29
Guinea-Bissau	0.014	3	0.1	−31	1
Senegal	0.060	38	4.75	−11	85
Average African group	0.027	12	1.63	−14	44
Ratio Egr/Agr	3	1	2	1	1/3

* Fish catches in tonnes/km² of fishing area.

reveals the order of importance of territorial waters affected by overfishing. Belgian, Dutch and Senegalese waters are on top which means that these countries have the greatest surplus of fishing capacity.

In connection with the nitrogen issue, the report of the United Nations Environment Programme (UNEP, 2002) reveals the existence of "dead zones" in seas and oceans. The European fishing areas are affected by this phenomenon (UNEP, 2002; EEA, 2003) which is caused by an excess of nutrients, especially of nitrogen, agricultural fertilizers, industrial and automobile pollution and waste.

In conclusion, even if the responsibility of the North for the pressure on the world fisheries is three times higher than the South, the impacts are largely equivalent: there is no margin any more for further development. Fishing is a matter of sustainable management of world resources and should not be confined to the "conquest of new spaces" as it is the case for other ongoing globalization issues.

4. Discussion and conclusions

To conclude, we would first like to come back to what our research shows about the use of indicators in this type of comparison. Then, we will discuss the most essential point for sustainable development i.e. the results obtained on the impacts of both country groups in the perspective of their current and future development patterns.

4.1. The analysis with indicators has some limits

First, inaccuracies result from the data sources, particularly data on African countries. In our results we noted on several occasions similarities between the data measured within a same group. We should examine if this phenomenon is not influenced by biases.

There are also mutual influences between the indicators, they are not all independent from each other. Pressures on a factor induce impacts on the fragility and vulnerability of others. CO_2 influences climate which, with territorial variations, influences rain distribution, water availability and gradually biodiversity. Water availability has, together with nutrient concentration, an impact on biodiversity and the fish stocks. Besides, all those issues have a direct or indirect impact on the potentialities for a sustainable human development.

Moreover, both groups of results also raise questions about the common use of indicators in extremely different situations (the case of "land use" for example), although this global comparability is common place in many studies. Additionally the aggregation at national level also raises questions: in some cases (water for example) a national indicator or its local distribution provide very different pictures of the situation. An obvious result of our research is that our various attempts to identify or build adequate indicators revealed that the results are under strong influence of the choice of the indicators (analysed problems, calculation per capita, per ha, etc.). This illustrates the possible variability of political conclusions to be drawn from reports based on several sets of indicators. The indicators used here were not only selected because they were available, as it is often the case, but rather according to a reasoning centred on the *degree of disturbance of nature*; several indicators were thus especially calculated for this article.

4.2. What are the conclusions for sustainable development in Africa?

Beyond the variety of results, a major piece of information can be drawn from this research: despite major differences between the environmental impacts of both country groups – Europe having a higher impact – the differences are often smaller than the differences between the compared indicators of economic development of both groups. In other words, the African countries seem to have proportionally a higher impact on environment per produced unit of wealth.

This result should not be surprising. First, it is well-known that the connection between impacts and the creation of economic wealth tends to weaken at high levels of GDP. This phenomenon is well documented in some cases at least (polluting emissions in the air for example) for the Western countries over the last decades. Our research extends this result to the six themes assessed in our research, as far as national indicators are concerned, which does not mean that at local level the results cannot be different. We discuss this result further in the next point, but let us point here to partial explanation of this major tendency, the very imperfect character of economic indicators to measure the activity in underdeveloped countries, considering the importance of the activities that are not taken into account because they are external to the market (Kestemont and Kerckhove, 2010). Second, the export outside Europe of polluting and natural resources consuming activities and the import of the products through trade shifts tends to decouple the responsibilities from the impacts. Finally, we would like to illustrate these three phenomena by means of our results as well as through external references.

4.3. "Overconsumption" of the environment in comparison with economic development

Altogether, these results suggest the "overconsumption" of the environment in comparison with economic output. Among the indicators that we considered, those related to fisheries are particularly alarming in this respect. Considering the limits of the environment in which these activities are carried out and if the modes of action remain unchanged, fishing is an activity for which there is not much nature left to conquer for development. In other words any improvement in the fish supply will have to be accompanied by "real progress", rather than by ultimate conquests of man on nature.

From a wider point of view, a comparison of Jackson and Michaelis (Jackson and Michaelis, 2003) between the countries of the North and of the South considered several parameters related to health, environment and consumption. These authors state that the ratio of the indicators of symbols of wealth, like the number of cars or of computers per capita, amounts to 25. The difference in attacks on the environment (ratio of 3) is less pronounced than the difference in responsibility (ratio of 7), which is itself less visible than the visible symbols of development through consumption. Let us note that these orders of magnitude, similar to those of our results, can reinforce the psychological attraction of the Western development patterns whose advantages are more manifest than their disadvantages.

4.4. Biases in the economic indicators

The criticisms of economic indicators as indicators of development are now well-known in the field of sustainable development and we won't come back to them here. But for some health indicators directly related to human development (like infant mortality for example), disproportions between the European and African results are definitely more significant than those related to the impacts on environment. In the context of the natural resources, a bias is induced by the fact that most of the comparisons by issues reveal an apparent "exploitation reserve" of the nature in the South as it is not exploited within the economic market. However, the globalization could accelerate this "nature rush" and could give an impression of growth whereas it is only about integrating in the economy a "free" production of nature, not to mention that this involves considerable impacts on the social organization of the countries.

4.5. Export of the impacts on environment out of the economically rich countries

For a series of issues, there are impacts that are transferred from the economically rich countries to third-world countries, a phenomenon that Martinez-Alier calls transfers of environmental costs (Martinez-Alier, 2002). As regards the localization of the impacts (local or exported), pressures directly exerted by the activities of the group of the North have a direct impact on the biodiversity, the fisheries, the water and the atmosphere in the South. The opposite is not true yet, hence the concept of ecological debt.

Nevertheless, for water, nitrogen and land use the direct impacts are rather local. However, the range gets wider if the indirect influences, resulting from trade (for example cultivations requiring much water or manure) are included. As a consequence, a country can undergo important local disturbances only for export purposes. Thus, the relatively even contrasted ratio between the two country groups concerning fishing for which the relatively high intensity in the African countries hides an important international trade.

Various methods try to take these various influences into account. In theory, it is the case for the concept of ecological footprint developed by Wackernagel et al. (2000). Works on the ecological deficit (idem), the exchanges of "embedded CO_2" in the import/export of finished products (Muradian et al., 2002; Ahmad and Wyckoff, 2003), the application of the satellite accounts to the economic input/output tables (Leontief, 1970; Vandille and Zeebroeck, 2003; Wiedmann et al., 2006; Turner et al., 2007) works on the total need of material, show an increasing share of environment imported by the countries of the North. The economic development of the North would then not only be the result of a more efficient use of the resources (a factor that has been put forward in the decoupling of the impacts and the economic growth) but also of an increased capacity to exploit the environment of the North as well as of the South. "Local and unpleasant" pollutants, like SO_2 (those which confirm the assumption of an environmental Kuznets curve (Harbaugh et al., 2002) according to which certain kinds of pollution decrease from a certain level of income) are those whose share of "imported" emission compared to national emissions increase most quickly to reach a ratio of 80 for The Netherlands in 1994 (Muradian et al., 2002). For this kind of pollutants, globalization undoubtedly represents the best opportunity of delocalization aiming at "moving away" the negative environmental impacts. However the reasons for delocalizing are numerous and the impacts on environment are only one part of it. Moreover, Africa is less proportionally affected by these phenomena than quickly and massively industrializing regions.

To conclude, all these results indicate how important impact mitigation efforts are for the sustainable development of Africa, now and in the future. In the present, if we consider some direct restrictive factors for the well-being of the populations. In the future, considering that, far from having tremendous "reserves" of environmental resources (according to some clichés of more "natural Africa"), the countries and the indicators show on the contrary that the pressures seem proportionally higher per produced unit of wealth. We showed that these indicators should be put into perspective but we also think that these results deserve more attention. Like the well-known results on the disproportion of the global disturbances related the greenhouse effect, they indicate that continuing with the development patterns of the North leads to a dead end for the global environment and population. This observation about climate is compared with several environmental problems considered at a global level which are less popular but not less alarming, like the disturbance of the nitrogen cycle or the biodiversity. If this evolution would go on, it would not only harm the global environment but also and above all affect proportionally more strongly the environment in the South: two additional reasons to maintain the difficult purpose of sustainable development.

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