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Historical Analysis of EPI in Colombia (2006-2014): Challenges on Environmental Information

Análisis histórico del EPI para Colombia (2006 a 2014): retos de la información ambiental

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ABSTRACT

The use of environmental indicators has been established as a way of addressing different variables and objects of analysis, including the complexity of biodiversity and ecosystems along with human wellbeing. Since 2006, the Environmental Performance Index has been used, ranking countries according to status of various indicators. Colombia has been included in all evaluations with variable results in its ranking. We examine some aspects that vary through the years in terms of the index and the performance of Colombia in evaluations from 2006 to 2014, mostly because Colombia had excellent scores at the beginning of the index measure, but decrease notoriously in the last ones that have made. We found that the historical evaluation of the EPI had differences in its structure, with a greater reliability on international databases rather than national information, as well as a continuum change of the types of variables used for the indicators. On an international context, Colombia's ranking variation reflects the differences in sources and accessibility of data. As useful as indexes might be to monitor and manage of resources, it is important to analyse each evaluation as much more than just the best and worst indicators, but rather to look at the sources, types of variables, ad context of each evaluation.

KEY WORDS: indexes; environmental indicators; sustainability; database; performance.

RESUMEN

El uso de indicadores ambientales se ha establecido como una forma de abordar diferentes variables y objetos de análisis, incluida la complejidad de la biodiversidad y los ecosistemas junto con el bienestar humano. Desde 2006, se ha utilizado el Índice de Desempeño Ambiental (EPI), clasificando a los países según el estado de varios indicadores. Colombia se ha incluido en todas las evaluaciones con resultados variables en su clasificación. Examinamos algunos aspectos que varían a lo largo de los años en términos del índice y el desempeño de Colombia en las evaluaciones de 2006 a 2014, teniendo en cuenta que Colombia tuvo un excelente desempeño en las mediciones iniciales del índice, pero su puntaje decreció sustancialmente hasta 2014. Encontramos que la evaluación histórica del EPI tenía diferencias en su estructura, con una mayor confiabilidad en las bases de datos internacionales en lugar de información nacional, así como un cambio de los tipos de variables utilizadas para los indicadores. En un contexto internacional, la variación de la clasificación de Colombia refleja las diferencias en las fuentes y la accesibilidad de los datos. Si bien los índices pueden ser útiles para monitorear y administrar los recursos, es importante analizar cada evaluación como mucho más que solo los mejores y los peores indicadores, sino más bien observar las fuentes, los tipos de variables y el contexto de cada evaluación.

PALABRAS CLAVE: índices; indicadores ambientales; sostenibilidad; bases de datos; desempeño.

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Introduction

Since 1992, the Agenda XXI - chapter 40, has emphasized the scarcity of environmental information and the lack of methods, and instruments for estimating and measuring sustainability indicators. This led to the construction of tools to provide robust and accurate environmental information that guide decision-making and follow-up at the international, regional and local levels (Hsu et al., 2013a). Public and private agencies have built a variety of indexes and indicators for understanding and unifying environmental, biological, ecosystemic, social, cultural, and economic information from a multidimensional perspective.

These indexes have become relevant for the measurement and monitoring of various indicators of sustainability, as well as starting points for the construction of knowledge (De Sherbinin et al., 2013). Among the strengths of multidimensional indicators and indices are: to diagnose problems from the analysis of trends or correlations, to generate early alerts for the prioritization of actions on management and information gaps (De Sherbinin et al., 2013). However, they still show certain limitations, such as comparing different scales of particular environmental conditions (*e.g.*, temperature, humidity, precipitation), biodiversity attributes (as species richness), or attributes such as ecological functionality and structure (Levin, 1992; Feld et al., 2009), as well as their traceability in time for evaluation, management and monitoring, while maintaining the greater complexity of their interactions. A big challenge in constructing ecological and biodiversity indicators, and translating to the well-being of humans, is the difficulty in defining which variables to measure, and even the measurement themselves, which leads to the use of "proxy" variables (Niemeijer and de Groot, 2008).

In the case of the variables related to sustainability, biodiversity and ecosystem services, according to the "Alliance on biodiversity indicators", the indicators involve direct measurement on different biological and ecological attributes (*e.g.*, number of species, landscape metrics, available habitat, etc.). Also including actions aimed at conservation and sustainable use, taking into account their practical meaning and political reach (Biodiversity Indicators Partnership, 2011).

Among the most recognizable indices are the Ecological Footprint (Rees, 1992; Wackernagel and Rees, 1997), the Oceans Health Index (Halpern et al., 2015), the Living Planet Index (WWF, 2016), and the Environmental Performance Index (EPI) (Hsu et al., 2013b). This latter index has been developed jointly by the Yale University Center for Environmental Policy and Law YCELP), the Information Network of the International Center for Earth Sciences at Columbia University (CIESIN) in the United States, and the support of the World Economic Forum (WEF) (www.epi.yale.edu/Epi). Regardless of the specific metric or index, it is vital to understand the differences between types of variables included in such multidimensional indicators, since although many may be useful in the abstraction and synthesis of processes and patterns of socioecological systems, some might not be comparable (Turnhout et al., 2007). However, to be able to integrate the information with other economic or social variables (Turnhout et al., 2007).

Although Colombia has made efforts to generate environmental and ecological indicators in line with international ones, there are few initiatives aimed at unifying, adding and understanding the available information they provide and upon which they are built, in an integrated way. In turn, this has resulted in heterogeneous databases, taken under different methodologies and purposes, which according to (Quiroga, 2007), makes explicit the need to formulate strategies to generate data and statistics that can systematically feed the indicators and information requirements of different thematic and at different scales.

The present research aims to analyse the EPI on the global scale and for Colombia, taking into account its historical trajectory from 2006 to 2014. Looking into the possible factors that could impact on the country's environmental performance, while seeking to identify the aspects in which the country prioritizes knowledge and actions around the management and conservation of biodiversity. This kind of descriptive analysis made around tools like EPI and country performance data, is looking to know how sensitive indicators are against different variables, available data and sources of information, and how scales and approaches may affect the measure of performance, and the historical index results. As a megadiverse country, Colombia's conservation and integrated management of biodiversity becomes a national priority, integrating monitoring of endangered and invasive species, state of resources natural and agroecosystems, and the impact of biodiversity conservation on human well-being, ensuring the conservation of biodiversity and ecosystem services at the local, regional and national levels (MADS, 2012).

Methods

Based on the EPI metadata available at www.epi.yale.edu, we resorted to an exhaustive search of primary source information regarding all parameters and estimators of the index. A search engine was also established for each indicator in four bibliographic databases using as denominators "Colombia" and the name and synonyms of the indicators, in order to reference the availability of information on the indicators included in the EPI. The databases used were Scopus, Science Direct (Elsevier), Redalyc y SciELO. The search engine is referred in Annex 1 (Historical Evaluation of EPI and Results for Colombia).

Our study encompasses from 2006 to 2014, aligned with the millennium development goals, which were replaced by sustainable development objectives (United Nations, 2017).

The historical evaluation was done in five aspects:

(1) The total number of indicators per evaluation.

(2) Indicators type or how the indicator is reported. Eight possible types of indicator were defined, while also identifying whether the value directly responds to the nature of the measured variable (*e.g.*, concentration of particulate matter in parts per million), or whether other types of units were used, a proportion (percentage, relation, ratio), percentage, score (ranking between ordered results), volume, rate or historical regression.

(3) Source: from where the EPI if gathering information, such as international organization, published article, academia, government or public sector, or non-governmental organization (NGO).

(4) Scale: within the national or global scope;

(5) Variable: direct, referring to the object of analysis from a specific approach, or indirect such as those products of mathematical modelling (which provide an estimate with different degrees of precision), probabilities or other product of analysis and spatial information crossing.

Afterward, it was synthesized based on two criteria: 1. Year-to-year change categories emphasizing the change of EPI to itself; 2. Historical performance of Colombia for each EPI assessed independently.

To evaluate the historical trajectory of the countries indicators at a national level, nine categories were built (Table 1), based on the performance percentage in the EPI results for each year (www.epi.yale.edu/Epi), adding the category of no data. We used an optimization or natural breaks of Jenks provided by the ArcGIS® software, to generate ranges according to the grouping of data with similar values, maximizing the differences between classes (de Smith et al., 2018). The historical results obtained for Colombia in the international evaluation were spatially compared with the scores obtained for the total number of countries evaluated.

Table 1. Global categories for EPI results comparison based on five categories of performance and a not evaluated category.

Performance group	Performance percentage	Evaluation category
1	> 95	Outstanding
2	91-95	Excellent
3	71-90	Good
4	51-70	Fair
5	30-50	Regular
6	29-11	Deficient
7	5-10	Bad
8	< 5	Poor
9	No data	Insufficient

Sources: this study.

Results and discussion

We present the results in two separate sections dealing with the historical detailed evaluation of the primary databases and information for the evaluation of index for the country and a second part, looking at the country's performance in the timespan the index has being going on.

Historical evaluation and environmental performance for Colombia

Throughout the five EPI assessments, in which Colombia has participated, changes in the parameters and measures addressed in each analysis were observed. These changes can respond to the international environmental agenda, the relevant environmental issues at the time of assessment, and the way in which the variables (models, indices and new studies) are addressed.

Some indicators are shared only in one or two EPI assessments, such as sulphur oxide emissions, and the index of water scarcity and forest loss (Table 2). While others have remained in all the evaluations, such as domestic air quality, sanitation level, and access to potable water. From 2008 onwards, pesticide regulation, marine protected areas, and protection of critical habitats were incorporated and maintained (Table 2).

Table 2. Indicators and analysis categories for historic EPI evaluation, according to indicator type, source, scale, and variable. For Indicator type (IT): Per: Percentage; Rel: Relate; Con: Concentration; Vol: Volume; Sc: Score; Reg: Regression; R: Rate. For Source: IO: International organization; AR: Journal Article; AC: Academy; GOV: Government (one country publishes data for the rest of evaluated countries); NGO: Non-governmental organization; EPIAct: EPI actualization. For information scale: N: National; G: Global. For Variable: D: Direct; M: Modelling; SA: Spatial analysis; Prob: Probability.

Indicator	IT	Sou	Sca	Var	2006	2008	2010	2012	2014
Child mortality	R	IO	N	D	X				
	R	IO	N	Prob				X	
	R	IO	N	Prob					X
Environmental burden of disease	Rel	IO	N	Prob		X	X		
PM10	Con	IO	G	M	X				
	Con	IO	N	M		X	X	X	
	Per	AR	N	M					X
Indoor air pollution	Per	IO	G	M	X	X	X	X	
	Per	AR	N	M					X
Regional ozone	Con	AR	G	M	X				
	Rel	AR	N	M		X			
Local ozone	Con	AR	N	M		X			
Sulphur dioxide emissions (ppb)	Con	GOV	N	M		X			
Sulphur dioxide emissions (Gg/1000 km^2)	Con	AR	G	M			X		
Sulphur dioxide emissions (GDP)	Rel	AR	G	M				X	
Sulphur dioxide emissions per capita	Rel	AR	G	M				X	
Ecosystem ozone	Con	GOV	G	M			X		
Nitrogen oxides emissions	Con	AR	G	M			X		
Non-methane volatile organic compound emissions	Con	AR	G	M			X		
Particulate matter (PM 2.5)	Con	AR	G	M				X	
Air quality (PM 2.5)	Vol	AR	G	M					X
Nitrogen loading	Con	AR	G	M	X				
Access to sanitation	Con	AR	G	M	X				
	Per	IO	N	D		X	X	X	X

to be continued

Table 2, continuation. Indicators and analysis categories for historic EPI evaluation, according to indicator [...]

Indicator	IT	Sou	Sca	Var	2006	2008	2010	2012	2014
Water quality index	Sc	GOV	N	M		X			
	Sc	AC	N	D			X		
Water stress	Per	AC	G	SA		X	X		
Wastewater treatment	Per	IO	N	D					X
Drinking water	Per	IO	N	D	X	X	X	X	X
Water Consumption	Per	AR	G	M	X				
Water scarcity index	Rel	IO	N	SA			X		
Change in water quantity	Per	AC	G	M				X	
Agricultural subsidies	Per	IO	N	D	X		X	X	X
	Per	AR	N	D		X			
Pesticide regulation	Sc	AC	N	D		X	X	X	X
Burnt land area	Per	AR	G	SA		X			
	Per	AR	G	SA		X			
Trawling intensity	Per	AR	G	SA		X			
Irrigation stress	Per	AR	G	SA		X			
Agricultural water intensity	Per	IO	N	M			X		
Timber harvest rate	Vol	IO	N	D	X				
Growing stock change	Vol	IO	N	D		X			
	Rel	IO	N	D			X	X	
Forest cover change	Per	IO	G	D			X	X	
	Per	AR	G	SA				X	
Forest loss	Per	AC	G	M				X	
Overfishing	Sc	IO	N	D	X				
Trawling intensity	Per	AR	G	D		X			
	Per	EPIAct	G	D			X		
Marine trophic index	Sc	AR	G	D		X			
	Sc	NGO	G	D			X		
Fish stocks overexploited	Per	NGO	G	D				X	X
Coastal shelf fishing pressure	Vol	NGO	N	D				X	
	Per	NGO	G	D					X
Ecoregion Protection	Per	AC	N	D	X				
Wilderness Protection	Per	AC	N	D	X				
Conservation risk index	Sc	NGO	N	D		X			
Marine protected areas	Per	NGO	N	SA		X	X		
	Per	EPIAct	N	SA				X	
	Per	AC	N	SA					X
Critical habitat protection	Per	NGO	N	D		X	X	X	X
Effective conservation	Per	AC	G	D		X			
Biome protection	Per	AC	N	SA			X		
	Per	EPIAct	N	SA				X	
Terrestrial protected areas	Per	AC	N	SA					X
Energy efficiency	Rel	IO	N	D	X				

to be continued

Table 2, continuation. Indicators and analysis categories for historic EPI evaluation, according to indicator [...]

Indicator	IT	Sou	Sca	Var	2006	2008	2010	2012	2014
CO_2 per GDP	Rel	GOV	N	D	X				
	Rel	IO	N	D				X	
Renewable energy	Per	GOV	N	D	X				
	Per	IO	N	D				X	
Emissions per capita	Con	IO	N	D		X			
	Rel	IO	N	D			X	X	
CO_2 emissions per kW h^{-1}	Rel	IO	N	D		X	X	X	
Industrial carbon intensity	Rel	IO	N	D		X			
Trend in carbon intensity	Reg	IO	N	D				X	
Change in trend in carbon Intensity	Reg	IO	N	D				X	
Trend in CO_2 emissions per KW	Reg	IO	N	D				X	
Energy access	Reg	IO	N	D				X	

Sources: this study

Change categories per year

One of the most noticeable changes among the 5 years in which EPI evaluation has taken place comes from the type of information, be it primary or secondary, where the indicator "regulation of pesticides" has been the only one developed and monitored by the EPI team with direct information. All other indicators are feed on secondary information. We present the year to year change based on the five aspects (see Methods).

Indicator change

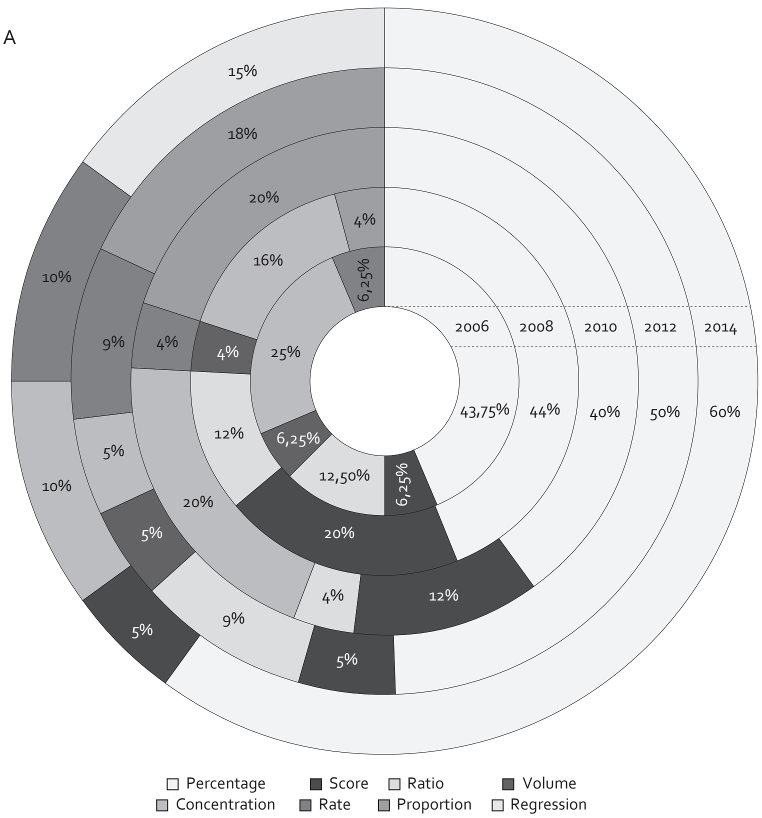
This presented the most significant historical differences, not only in the number of indicators each year but also in the themes or objectives. For 2006, 16 indicators were evaluated, six were maintained in 2008, and 19 new indicators were added, while in 2014, 12 indicators were maintained, and eight added. Only four remained during all assessments and are the only ones on which a direct multitemporal comparison can be made, bearing in mind that some have changed their reference source.

Since 2010, indicators have been homogenized, changing units of analysis or reference sources, and taking similar variables during the following two evaluations (Table 2). This trend towards homogenization of indicators and measurement factors reflects the fact that EPI would have defined core indicators in future assessments (http://archive.epi.yale.edu/our-methods). On the other hand, changes in the indicators from year to year may be influenced by the difficulty in the availability and accessibility of primary and secondary information (Hsu et al., 2013a). It would be very informative is some information could be collected regarding why the appearance of new indicators and the drop of other, as to point to possible knowledge or methodological gaps.

Indicator type

The "percentage" predominates in all indicators, with the EPI 2014 evaluation representing half of the indicators, having a historical minimum of 40% (2010) (Figure 1). "Rate" has increased over time, presenting a higher relevance in monitoring systems on the indicators themselves. Also increasing is the use of scoring systems (Table 2) (in the regulation of pesticides and marine trophic index, for example), which provides a categorization of variables. Other types, such as volume, proportion, and ratio were not used in the last EPI, while regressions of historical data were newly included (Figure 1A).

The use of different indicators can be inconvenient when approaching a time series analysis of the variable. As such, indicators that have taken the country's GDP as a unit of reference take for granted a correlation between economic growth and markets, with environmental performance, despite being variables that do not behave similarly, nor



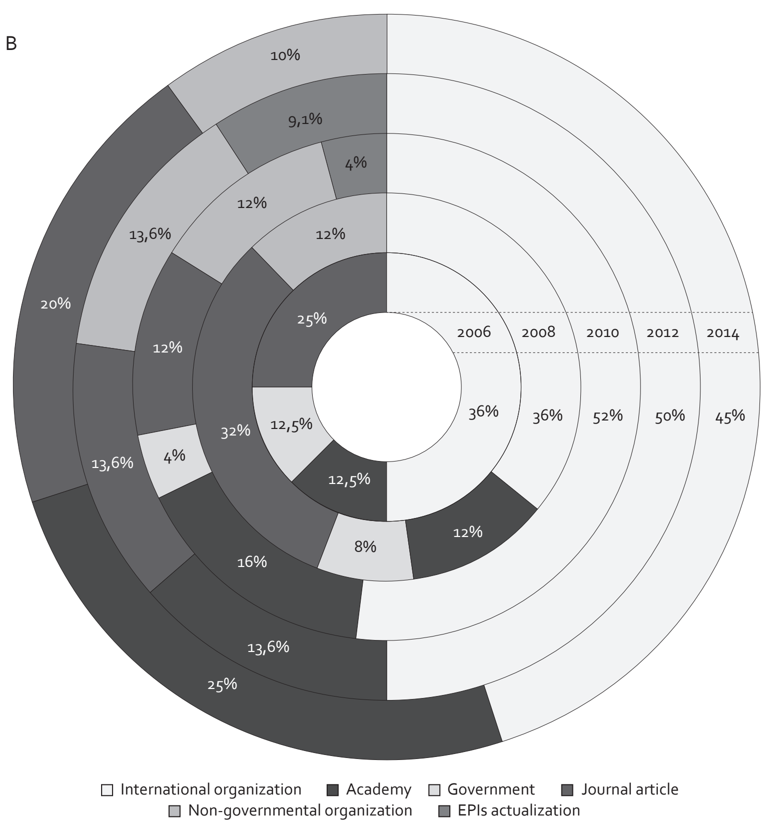
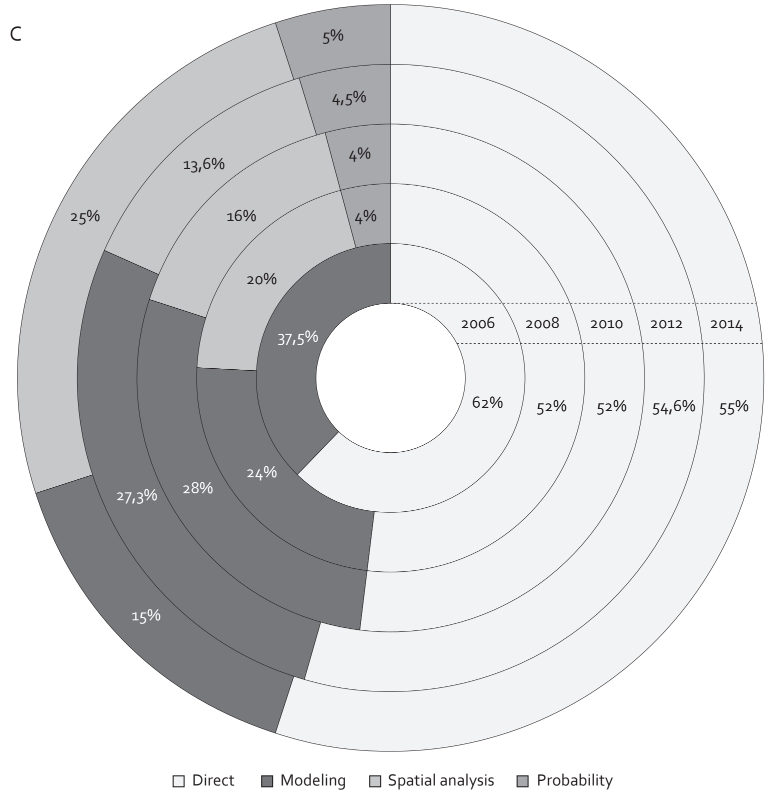


Figure 1. Yearly percentage of EPI´s analysis categories: a. Indicator type; b. Source of information; continued.



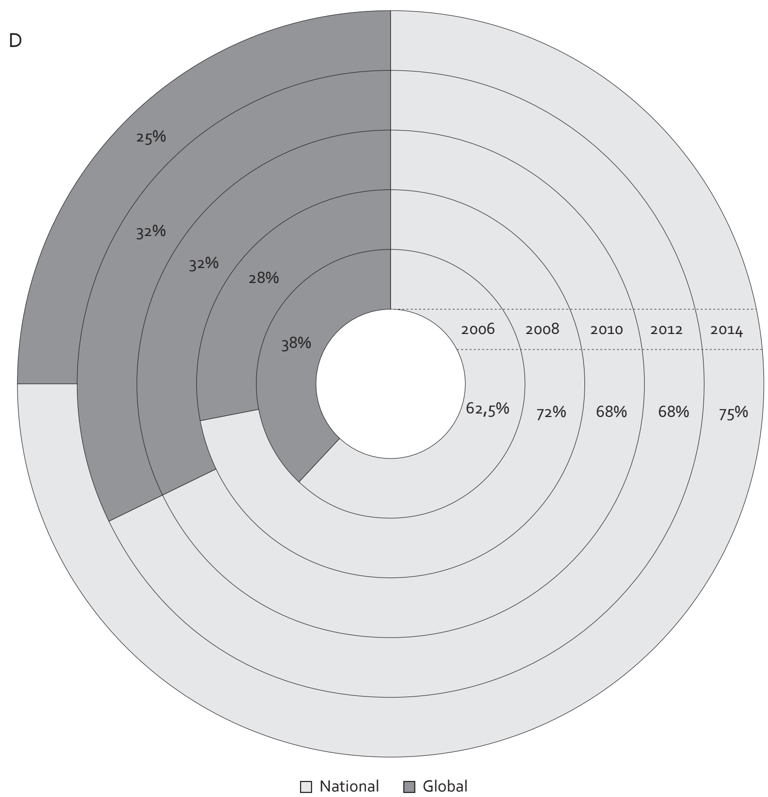


Figure 1 continuation. Yearly percentage of EPI´s analysis categories: c. Variable; d. Scale. Source: this study respond to the same conditions (Costanza et al., 2009). Costanza et al. (2009) argue that using indicators related to such parameter might not be the most adequate since GDP represents exclusively the economic sector limiting the comparisons to such dimension when ecosystems respond to conditions and aspects not only related to market forces. As an alternative to classical GDP, there are similar units of measure such as corrected GDP, green GDP (Li and Fang, 2014), and the Sustainable Economic Welfare Index (Cobb, 1989), which take into account other parameters for assessing country-wide performances.

Source

Of the six classes analysed (Fig. 1b), a prevalence of consultation with international organizations was observed, as well as the increase in information provided by the academic institutions, where it doubled between 2006 and 2014. Within international organizations, the United Nations and its respective agencies and programs (World Health Organization, UNICEF, UNEP, UNDP, UNEP), the World Bank, and the Organization for Economic Co-operation and Development (OECD) are commonly consulted. National agencies reporting to these types of organizations can generate different incentives. For example, developing countries intending to be part of the OECD would be interested in showing better management of their economic, industrial and environmental resources (OECD and ECLAC, 2014). According to the OECD´s Environmental Performance Assessment for Colombia, the country should improve on environmental indicators investment, financing of marine protected areas, and increased coverage of terrestrial protected areas, in line with the more recent 2016 EPI evaluation and other studies (Castaño-Uribe, 2008; IDEAM, 2018; Romero-Torres and Acosta, 2012; UICN, 2016).

Scientific article incorporation in the EPI assessment is still low for Colombia (Figure 1B), while NGOs have remained constant throughout the evaluations (10% -14%). In contrast, in recent EPI, State or public information has not been taken incorporated in the analyses (Figure 1B), which could reflect the delegation of acquiring such data to specific research institutes, such as the SINA (Sistema Nacional Ambiental). Also, it should be taken into account that reporting specific parameters might be of different priority to different scales. For example, even though the indicator "infant mortality" in the department of La Guajira in Colombia, has been addressed by different sources like indigenous organizations, national media, the Ministry of Health, and international organizations such as UNICEF; all of them present discrepancy in the data. Some report 10,000 deaths from 2007 to 2015 (Wayuu Indigenous Authority), other 5,000, and another report only 294 (www.dane.gov.co). This would call for two actions, one, to integrate all possible sources into a public database to not only gather as much information as possible but also to assess the metadata of such information. Two, to look for independent information such as academic research, that might help provide a better picture of each indicator. On the other hand, the incorporation of academic institutions and published articles might also explain the slight rise in the incorporation of models and other statistical analysis, such as with the project "Sea Around Us" (Pauly, 2007), or the indicators of Climate and Energy presented in EPI 2014 which mainly information sources include World Bank (2013), United Nations (2007), IEA (2013) and IPCC (2013) data.

Scale

The dominant scale is the national level, with over 60%, and a maximum of 75% in 2014, compared to 25% about global data. In recent years, more articles have ventured to undertake global analysis, probably encouraged by the accessibility of structured, freely accessible databases, such as in fisheries related issues (Pauly, 2007), air quality (van Donkelaar et al., 2010), and change in global land cover (Hansen et al., 2013); allowing a global approximation to the indicators.

While data obtained at the national level can vary in methodological criteria concerning comparisons with other countries, global studies overcome such caveat and present as well a unified modelling and analysis framework. For others, national referents may not be as adequate, such as catches of industrial and artisanal fishery resources (which is voluntary in

Colombia), probably leading to underreports (Watson and Pauly, 2001).

Analyses on a global scale are not free of considerations. For example, for the change in forest cover, for 2014 EPI´s evaluation, Hansen et al. (2013) defined "Forest" as the areas represented in a continuous canopy cover greater than 50%, evaluating the change from the year 2000 to 2012. As Chazdon et al. (2016) mention, the pure definition of what is a forest is still up for debate, on granting forest cover does not define functioning (Wilkie et al., 2011), which may depend on other parameters that could be affected at smaller scales, such as selective logging, expansion of illicit crops, or the establishment of commercial forest plantations (Fitzherbert et al., 2008; Armenteras et al., 2011, 2017; de Andrade et al., 2017). Not only geographical scale imposes caveats to global studies, but also temporal ones. For example, for modelling of the air quality indicator (exposure / exceedance of PM 2.5) (van Donkelaar et al., 2010), national data are supposed to be included in the global databases almost on real time, for which some regions may be limited by the quantity and quality of information, especially in areas where measurement is still insufficient.

Variable

Direct variables are present in more than 50% of the indicators, with modelling following closely (Figure 1C) in all years, except for 2014. Along with modelling, spatial analysis has come a common type of variable used in addressing the EPI indicators for Colombia, with up to 25% in 2014 (Figure 1C).

Stable types of variables in the EPI analysis, such as direct ones, may differ in collection criteria and methodologies, which could also show limitations on gathering very robust and large-scale information for accurate modelling. However, these weaknesses are reduced by incorporating types of spatially explicit variables, which integrate a detailed scale (point data such as population concentration, protected area boundaries, water bodies), and macro data (*e.g.* climate, temperature, precipitation) (Levin, 1992), which can generate a multidimensional result with greater integrity.

Colombia in the EPI

Colombia has varied its position and score in the EPIs from ninth place in 2006 (with 88.3 points) to the 85th position in 2014 (50.67 points). For EPI 2006, Colombia had an outstanding environmental performance in South America, performing above 90% in six of the 16 indicators evaluated, and surpassing neighbouring countries such as Peru, Brazil, and Panama; and equating with French Guiana, Costa Rica and Canada at the continent (Figure 2). For 2008, Colombia was also in the best performing class (Figure 2), but in 2010, environmental performance for all of the Americas declined, with Colombia and French Guyana being the only countries with outstanding environmental performance in the region. In both 2008 and 2010, Colombia ranked among the top 10 countries worldwide, although in both years there was insufficient information to build two indicators (Table 3). After that, Colombia began to decline, falling to the 27th position (Figure 2).

The low country performance in 2012 could be related to the lack of evaluation of most Central Africa countries, which had the lowest results in previous EPIs. By 2014, Colombia placed in the average global environmental performance (85 out of 178 countries), along with most of the countries of the American continent, except for Canada, the United States, French Guiana, and Chile. Although there are differences in the number of countries included in each evaluation (Figure 2), there seems to be no direct relationship with countries performance in relations to Colombia´s position, since countries with similar characteristics in ecosystems, economics, and socio-cultural aspects (*e.g.*, Ecuador, Peru, Venezuela) Quiroga (2007) have always been included.

Table 3 examines the national historical process in EPI scores according to the performance groups define in Table 1, based on the target range percentage of each indicator, as defined by Hsu et al. (2013a), in which the country performance is described from 0 to 100, with 100 the closest value to the ideal. For example, if the goal of the Marine Protected Areas indicator is to achieve 10% representativeness of the Economic Exclusion Zones (EEZ) (200 miles from

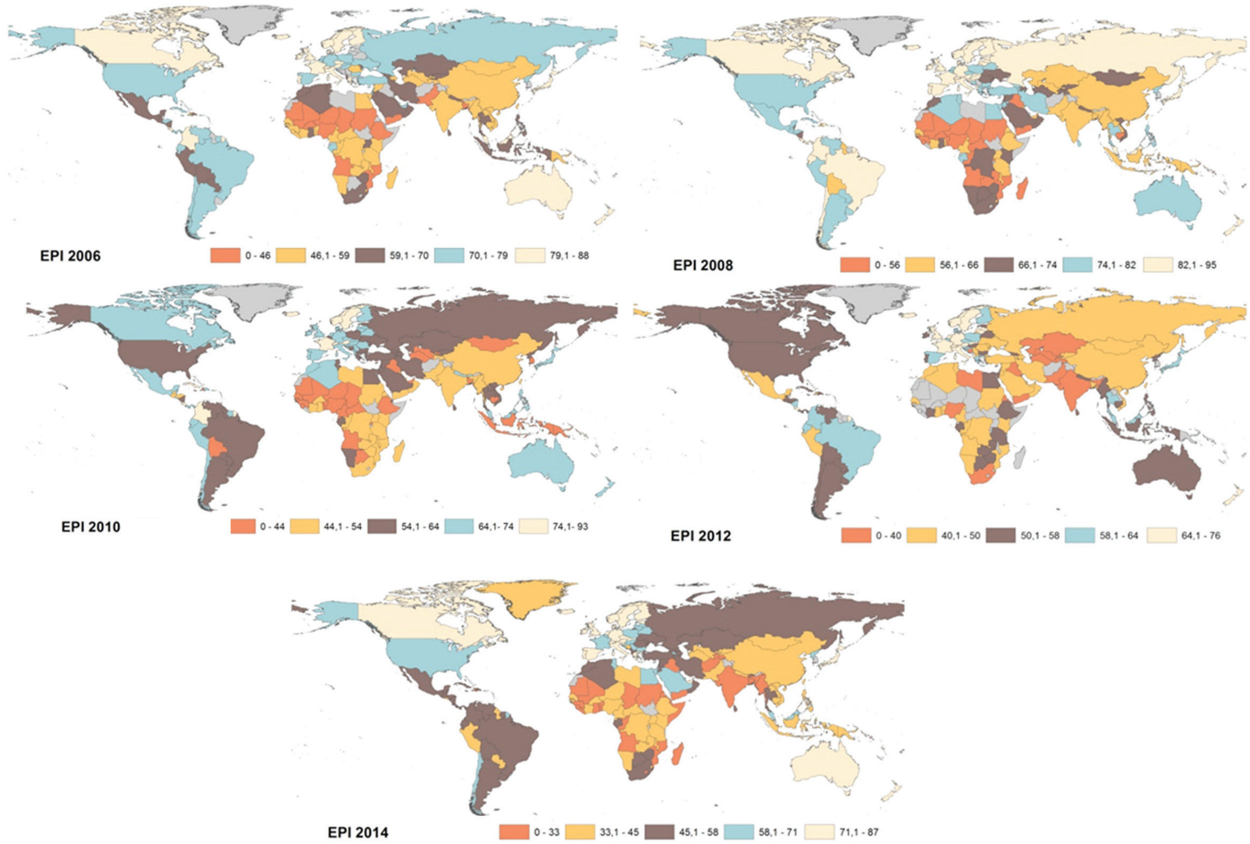


Figure 2. EPI Historical trajectory worldwide (from lower to higher standings, according to Table 1). Total of country including in the evaluation are indicated below: 2006:133; 2008:149; 2010:163; 2012:132; 2014:178. Grey: country not included in evaluation, orange: 0-33/ insufficient, yellow: 33.1-45/low, brown: 45.1-58/regular, blue: 58.1-71/acceptable, cream: 71.1-87/excellent. Sources: this study.

Table 3. Performance for Colombia EPI parameters (in percentage) according to the historical evaluations from 2006 to 2014, grouped based on Table 1 values.

Performance group	2006	2008	2010	2012	2014
1. Outstanding	Timber harvest rate	Water stress	Water scarcity index	Particulate matter (PM 2.5)	Marine protected areas
		Growing stock change	Agricultural water intensity		
		Trawling intensity	Trawling intensity		
	Nitrogen loading	Local Ozone	Pesticide regulation	Marine protected areas	Electricity access
		Regional ozone			
		Sulphur dioxide emissions	Forest cover change		Air quality (PM 2.5)
	Agricultural subsidies	Particulate matter		Emissions per capita	
		Irrigation stress	Biome protection		Exceedance PM 2.5
		Intensive Cropland			

Continues

Table 3, continuation. Performance for Colombia EPI parameters (in percentage) according to the historical evaluations from 2006 to 2014, grouped based on Table 1 values.

Performance group	2006	2008	2010	2012	2014
2. Excellent	Water consumption	Environmental Burden of Disease	Urban particulates	Pesticide regulation	Pesticide regulation
	Child mortality	Conservation Risk Index			
	Energy efficiency	Effective Conservation			
		Burnt land area	Marine protected areas		
		Emissions per capita			
3. Good	Particulate matter (PM 2.5)	Access to sanitation	Indoor air pollution	Biome protection	Terrestrial protected areas
	Drinking water access	Drinking water access	Drinking water access		
	CO_2 per GDP	Indoor air pollution	Indoor air pollution		
	Access to sanitation	Marine protected areas	Marine trophic index		Terrestrial protected areas
		Pesticide regulation		Renewable energy	
	Ecoregion Protection	CO_2 emissions per kWh	Greenhouse gas emissions		Indoor air pollution
		Industrial carbon intensity			
4. Fair	Indoor air pollution	Water quality index	Environmental Burden of Disease	CO_2 per GDP	Coastal shelf fishing pressure
			Sulphur dioxide emissions	Forest loss	Critical habitat protection
			Water quality index	Forest cover change	Trend in Carbon Intensity
				Sulphur dioxide emissions	
4. Fair	Indoor air pollution	Agricultural subsidies		Sulphur dioxide emissions per capita	
			Water stress	Change in water quantity	Child Mortality
				Critical habitat protection	
				Child Mortality	
5. Regular	Overfishing	Critical habitat protection	Nitrogen oxides emissions	Drinking water access	Drinking water access
	Regional ozone		Non-methane volatile organic compound emissions	Coastal shelf fishing pressure	CO_2 emissions per kWh
	Renewable energy		Critical habitat protection	Indoor air pollution	Change in trend in carbon intensity
			CO_2 emissions per kW h^{-1}		

Continues

Table 3, continuation. Performance for Colombia EPI parameters (in percentage) according to the historical evaluations from 2006 to 2014, grouped based on Table 1 values.

Performance group	2006	2008	2010	2012	2014
6. Deficient	Wilderness Protection	-	Ecosystem ozone	Agricultural subsidies	Agricultural subsidies
			Agricultural subsidies	Access to sanitation	Forest cover change
				Fish stocks overexploited	Access to sanitation
				CO_2 emissions per kWh	
7. Bad	-	-	-	-	Fish stocks overexploited
8. Poor	-	-	-	-	Wastewater treatment
9. Insufficient	-	Marine trophic index	Growing Stock Change	Growing Stock Change	-
Total indicators evaluated	16	25	25	22	20
Colombia score	80,4	88,3	76,8	62,63	50,67
Global ranking	17	9	10	27	85

Sources: this study

the coast), in line with Aichi goal 11 and Sustainable Development Goal 15 (UICN, 2016), achieving 100% performance in the indicator would be to guarantee the 10% protection over these (objective fulfilled).

For 2006, Colombia showed a performance above 50% for 12 of the 16 indicators evaluated (Table 3), being deficient in those related to fisheries, regional ozone, renewable energies, and wildlife protection. As for the outstanding indicators, forests, water resources and agriculture are highlighted, with values very close to the established objective. In 2008, the year with best EPI ranking, nine of the 25 indicators evaluated were above 95% performance and five others with more than 90% (Table 3), even when no data was incorporated into one indicator, marine trophic index, where no national information was found (González pers. obs., 2016).

In 2012, eight of the 25 indicators were around the "tolerant" performance group, with indicators such as water resources and change in forest cover dropping form previously higher categories, (Table 3). By 2014, eight of the 20 indicators evaluated were below 50%, and for the first time, the country had indicators below 10%, with more indicators with regular and deficient performance, reducing the proportion of outstanding and good indicators to only five.

Although Colombia has made efforts to generate environmental and ecological indicators adhering to international standards, few initiatives aim to unify, aggregate and understand the information available in an integrated manner that is also useful at the local and/or national. This has resulted in heterogeneous databases, gathering data under little or poorly known metadata procedure, with different methodologies and different purposes. According to Quiroga (2007), makes explicit the need to formulate strategies to generate data and statistics that can systematically feed international indicators, attending the standards and requirements on various themes and at different scales, while working at a regional scale to procurer the best ways to communicate with policy and decision making entities. This implies, among other aspects, the growing need to generate effective information from different sources and approaches that feeds the development of policies and regulatory figures (Vihervaara et al., 2017), focused on the protection and sustainable management of the country's biological diversity, directly related to the welfare conditions of people, as mentioned in the National Policy for the Integral Management of Biodiversity and its Ecosystem Services (MADS, 2012).

Conclusions

Historical changes in indicators, sources, measurement and registration within the EPI, can make it difficult to track the national performance, although the two main objectives of the index Environmental Health and Ecosystem Vitality, and the categories are maintained (Hsu et al., 2013a, 2013b). Coupled with the incorporation of new analytical tools, such as spatially explicit analysis and the use of multi-temporal studies, offers a better understanding of environmental performance, integrating fine filter information (country-specific) and coarse filter information (such as image information and satellite sensors) could aid in evaluating the overall performance of countries or regions. Also, it´s important to underline the importance of remote sensing analysis that have been increasable used not only in this sort of exercises, but for understanding and monitoring high scale dynamics, and analyse change scenarios for low cost decision making, as Vihervaara et al. (2017) suggest. Taking into account these variations in the analysis and total score of the index offers the possibility to give a context for the decision-making and to determine ways to national entities and sources responsible for the careful and detailed recording of the information (Zuo et al., 2016). Caution is required when incorporating metrics or data that have been taken with varied objectives and methodologies, as they inherently will have different biases that will make comparison difficult (Suárez-Mayorga et al., 2007).

Our analysis of the EPI for Colombia allowed a broad perspective of the environmental performance of the indicators that evaluate. We strongly inquire about the information of national sources that report, register or act on the environmental indicators evaluated, in reference to their availability and quality; taking into account that current technologies represent an enormous potential not only in the dissemination of environmental information but in the empowerment of society as an active stakeholder, which should be more broadly communicated to society (Sutherland et al., 2012; Kays et al., 2015; Pascual et al., 2017; Costa et al., 2018; Lyver et al., 2018).

When using indicators in decision-making scenarios, and as references for information on ecological and biodiversity issues, it is key to address them from the objectives they pursue, the methodologies used, and the limitations they contain. The use of EPI, or other global indexes, as a tool to compare indicators with current scenarios, and the country's role in monitoring the state of ecosystems, provides detailed information on the relationship between environmental performance and the data that is used internationally for its construction, calling attention to knowledge and methodological gaps (Layke, 2009; Cetas e Yasué, 2016; van Kerkhoff et al., 2018).

For the UN Sustainable Development Objectives (www.un.org/sustainabledevelopment), the EPI framework becomes a transversal tool, making it desirable to match EPI indicators with those presented by the UN to generate a monitoring program that favour the evaluation of global environmental performance under the UN Agenda 2030 (United Nations, 2017). This kind of research is useful to estimate and understand how policy works at national scale according to international environment agenda and sustainable development goals, and how countries take indicators in practice, in order to reach and transform environmental issues and policies. According to the above, we suggest that "Top Down" actions are efficient, understanding them as the international agreements for addressing environmental goals in sustainability, giving the starting point for politic development represented in the identification and definition of environmental priorities, information gaps and the political actions that are needed for reach the global goals that have been defined. Nevertheless "Bottom up" actions, understood as the policies developed in local and regional scenarios, even as civil initiatives, could have more relevance in short and middle term, and also a most notorious impact, divulgation and appropriation, attaining to targets like cleaner energy production and use, waste reduction, or biodiversity conservation, to the extent that are actions where involving actors and stakeholders could be more effective and transforming.

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1. ALL(environmental performance index) AND TITLE-ABS-KEY(composite index) AND TITLE-ABS-KEY(-sustainability) OR AND TITLE-ABS-KEY(Colombia)) OR TITLE-ABSKEY(EPI)) AND (EXCLUDE(-SUBJAREA,“ENGI”) OR EXCLUDE(SUBJAREA,“BUSI”) OR EXCLUDE(SUBJAREA,“COMP”)) AND (EXCLUDE(SUBJAREA,“MATE”) OR EXCLUDE(SUBJAREA,“PSYC”) OR EXCLUDE(SUBJAREA,“IMMU”) OR EXCLUDE(SUBJAREA,“PHYS”)) AND (EXCLUDE(DOCTYPE,“cp”) OR EXCLUDE(DOCTYPE,“ch”) OR EXCLUDE(DOCTYPE,“ip”))
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