From Millennium Development Goals to Sustainable Development Goals.
Are we on track?

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*Abstract—*In the framework of the 2030 Agenda for Sustainable Development, a list of 17 Sustainable Development Goals (SDG) has been approved connecting the issues of multidimensional poverty, inequality and exclusion, and sustainability. Seven of these goals are referred to environmental sustainability, thus significantly increasing the weight assigned to this field in the previous Millennium Development Goals (MDG). The monitoring of sustainable development goals represents a challenge, especially for less developed countries, where a data revolution is needed to address the existing gap. In spite of this fact, this paper provides significant evidence about the existing differences in the benefits of development between countries, suggesting the need of further efforts aimed at "*leaving no one behind*" as stated in the first SDG report.

Keywords- SDG; sustainability; poverty; environment; performance; convergence

I. INTRODUCTION

The challenge of ensuring environmental sustainability, already included in the list of Millenium Development Goals (MDG), is now more evident since the new Sustainable Development Goals connect the issues of multidimensional poverty, inequality and sustainability. More specifically, while MDG considered four different environmental targets, this number has significantly increased in the SDG, which contain seven environmental goals (numbers 7, 9, 11, 12, 13, 14, 15, as summarized in Table I), monitored though 77 indicators.

Furthermore, the Paris Agreement (United Nations [1]), entered into force on 4 November 2016, sets out a global action plan to avoid dangerous climate change by limiting global warming, thus strengthening efforts to achieve SDG, particularly goal number 13.

Within this context, this paper aims at monitoring the environmental MDG paying particular attention to the most vulnerable people and countries. In section 2 a performance index is computed for both environmental and poverty goals, while in section 3 we analyze the existing relationships, testing for convergence and country effects. Finally, section 4 provides some concluding remarks.

TABLE I. MDG AND SDG

Millennium Development Goals	Sustainable Development Goals
1- Eradicate extreme poverty and hunger	1-End poverty in all its forms everywhere 2-End hunger, achieve food security and improved nutrition and promote sustainable agriculture 3-Ensure healthy lives and promote well-being for all at all ages
2- Achieve universal primary education 3- Promote gender equality and empower women	4-Ensure inclusive and equitable quality education and promote lifelong learning opportunities for all 5-Achieve gender equality and empower all women and girls 8- Promote sustained, inclusive and sustainable economic growth, full and productive employment and decent work for all 10- Reduce inequality within and among countries
4- Reduce child mortality 5- Improve maternal health 6- Combat HIV/AIDS, malaria and other diseases	6- Ensure availability and sustainable management of water and sanitation for all
7- Ensure environmental sustainability	7- Ensure access to affordable, reliable, sustainable and modern energy for all 9- Build resilient infrastructure, promote inclusive and sustainable industrialization and foster innovation 11- Make cities and human settlements inclusive, safe, resilient and sustainable 12- Ensure sustainable consumption and production patterns 13- Take urgent action to combat climate change and its impacts 14- Conserve and sustainably use the oceans, seas and marine r resources for sustainable development 15- Protect, restore and promote sustainable use of terrestrial ecosystems, sustainably manage forests, combat desertification, and halt and reverse land degradation and halt biodiversity loss
8- Develop a global partnership for development	16- Promote peaceful and inclusive societies for sustainable development, provide access to justice for all and build effective, accountable and inclusive institutions at all levels 17- Strengthen the means of implementation and revitalize the global partnership for sustainable development

II. MONITORING ENVIRONMENTAL GOALS

Despite the lack of information for the less developed regions and some limitations in data coverage and quality, the SDG database and report [2] provide information for a wide variety of countries. More specifically, a panel has been considered including 135 countries and six different five-year periods referred to 1990, 1995, 2000, 2005, 2010 and 2015.

Regarding the monitoring framework, a report by the Sustainable Development Solutions Network [3] emphasizes the need of simplicity, high frequency and disaggregation and the UN Statistical Commission [4] agreed a list of SDG indicators, subject to refinements and improvements as methods and data availability improve. In this context, our analysis includes the proportion of population with access to electricity, the proportion of population with primary reliance on clean fuels and technology, the renewable energy share in the total final energy consumption, the emissions of Carbon Dioxide ($CO2$), the proportion of urban population living in slums and the material footprint per capita. Furthermore, since the elimination of poverty is a meaningful goal for development, the poverty rate has also been analyzed.

In order to monitor the evolution of these goals measuring the level of achievement of the proposed targets, two different indicators have been computed: the cumulative rate of growth and the performance index, given by the following expressions:

Cumulative rate of growth: $r = \left(\dfrac{X_t}{X_{1990}} \right)^{\frac{1}{t-1990}} - 1$

Performance index: $I_t = \dfrac{X_t - X_{1990}}{X_t * - X_{1990}}$

where $X_t, X_{1990}, X*$ respectively denote the current and initial values of the considered variables, and the specific target in the case that it exists.

A classification of countries can be established according to the obtained results in both environmental and poverty indicators, as collected in Table II. In general terms, countries behave satisfactorily, especially with regard to poverty, as it has been stressed in some recent reports [2], [5], [6]. However, some difficulties are found regarding environmental goals as the electricity access, the evolution of carbon dioxide emissions and the percentage of population living in slums.

Since the behaviour of the considered indicators varies widely across countries and the achievement of the sustainable development goals is particularly important for poor regions and countries, in the next sections we estimate econometric models with the aim of providing empirical evidence referred to the following questions:

-Does economic growth impact environmental SDG?
-Does convergence exist?
-Are there significant country and/or time effects?

TABLE II. CLASSIFICATION OF COUNTRIES ACCORDING TO ENVIRONMENTAL PERFORMANCE AND POVERTY REDUCTION

		Environmental Performance		
		Low	Medium	High
Poverty Reduction	High	Australia, Comoros, Niue, Virgin Islands,	Austria, Cyprus, Grenada, Israel, Japan, Kuwait, Netherlands, Norway, Reunion, Seychelles, Spain	Andorra, Belgium, Canada, Cook Islands, Czech Republic, Denmark, Finland, France, French Polynesia, Germany, Greenland, Guam, Iceland, Italy, Luxembourg, Micronesia, Monaco, Rep. Moldova, Singapore, Slovakia, Slovenia, Sweden, Switzerland, Macedonia, United Arab Emirates, United Kingdom, Yemen
	Medium	Algeria, Angola, Argentina, Bangladesh, Belize, Benin, Bolivia, Botswana, Brazil, Burkina Faso, Cambodia, Cameroon, Chad, Ecuador, Eritrea, Ethiopia, Ghana, Guatemala, Guinea, Haiti, Honduras, Indonesia, Kenya, Madagascar, Malawi, Malaysia, Maldives, Mali, Mexico, Mozambique, Namibia, Nepal, Pakistan, Panama, Paraguay, Peru, Senegal, Sierra Leone, Sri Lanka, Thailand, Togo, Trinidad Tobago, Uganda, Tanzania, Venezuela	Afghanistan, Bhutan, Burundi, Central African Republic, Chile, China, Colombia, Costa Rica, Dem Rep Congo, Dominican Republic, Egypt, Fiji, Greece, Guyana, India, Iran, Jamaica, Jordan, Kazakhstan, Kiribati, Libya, Mauritania, Morocco, Niger, Philippines, Portugal, Saint Lucia, Saudi Arabia, South Africa, Swaziland, Tonga, Tunisia, Turkey, Uruguay, Vietnam, Zambia	Aruba, Azerbaijan, Bahrain, Belarus, Bulgaria, Cote d'Ivoire, Croatia, Estonia, Hungary, Ireland, Kyrgyzstan, Lithuania, Romania, Rwanda, Serbia, Syria, United States, Uzbekistan
	Low	Antigua and Barbuda, Bosnia and Herzegovina, El Salvador, Georgia, Mauritius, Montserrat, Nicaragua, Nigeria, Papua N Guinea, Zimbawe	Barbados, Samoa	Marshall Islands, Palau, Puerto Rico, Russian Fed, Sudan, Tuvalu

Note: The classification of countries with regard to Environmental Performance and Poverty Reduction has been established according to the level accomplishment (%) of the corresponding targets: "High" if the level overcomes 75%, "Medium" for levels between 50% and 75% and "Low" otherwise.

III. CONVERGENCE ANALYSIS AND PANEL EFFECTS

In order to answer the previously proposed questions, we consider a panel database referred to 135 countries and 6 five-year periods from 1990 to 2015.

The convergence analysis has been performed for each environmental indicator, testing if the corresponding cumulative rate of growth is inversely related with the initial values. As summarized in Table III, although the goodness of fit (measured through the coefficient of determination) is quite poor, all the estimated coefficients show the expected negative sign.

Furthermore, the regression also includes the Gross Domestic Product (GDP) rate of growth, included in the MDG database, which appears to significantly affect the access to electricity (possitively) and the population living in slums (negatively).

TABLE III. ENVIRONMENTAL SDG: CONVERGENCE ANALYSIS

Cumulative rate of growth of	Estimation results		
	Estimated coefficient of GDP Growth	*Estimated rate of convergence*	*R squared*
Proportion of population with access to electricity	0.47 (***)	-0.1 (***)	0.09
Proportion of population with primary reliance on clean fuels and technology	0	-0.01 (***)	0.32
Renewable energy share in the total final energy consumption	0,08	-0.03 (***)	0.17
Emissions of Carbon Dioxide (CO2)	-0,02	-0.27 (***)	0.10
Proportion of urban population living in slums	-0,17 (***)	-0.02 (***)	0.49
Material footprint per capita	0.03 (**)	-0.01 (***)	0.08

***significant at 1%; **significant at 5%; * significant at 10%

A more detailed analysis through panel estimation allows the identification of specific country and year effects. In this case, the dependent variable is the level of each environmental indicator and Table IV collects the main estimation results under the random effects hypothesis, which seems to be the most suitable option according to the Hausman test.

The empirical evidence confirms the impact of economic growth in the access of electricity and the population living in slums, thus confirming the previous results. Moreover, in this case, significant impact is also found over the emissions of carbon dioxide.

Given that this indicator has been identified as one of the main factors affecting the climate change, a more detailed analysis has been performed on carbon dioxide emission, whose econometric modeling and forecasting can be found in several works as Koirala et al [7], López et al [8], Pérez & López [9], among others. In general terms, these works confirm the need of new models of development and better environmental policies to avoid the costs of inaction both in economic and human terms.

TABLE IV. PANEL ESTIMATION OF ENVIRONMENTAL SDG

Indicator	Estimation results	
	Estimated coefficient of GDP Growth	*Significant time effects*
Proportion of population with access to electricity	0.18 (***)	2000 (+) 2010 (+)
Proportion of population with primary reliance on clean fuels and technology	0.07	2005 (-) 2010 (-)
Renewable energy share in the total final energy consumption	-0.02	2000 (+)
Emissions of Carbon Dioxide (CO2)	0.004 (**)	2000 (+) 2005 (+)
Proportion of urban population living in slums	0.33 (*)	2000 (+) 2005 (+) 2010 (+)
Material footprint per capita	0.03	

***significant at 1%; **significant at 5%; * significant at 10%

According to the SDG panel database, CO2 emissions increase with economic growth and decrease as the share of renewable energy raises, thus confirming the findings of previous works [8] and emphasizing the need to promote broader energy access and increased use of renewable energy, as stated in SDG goal 7.

IV. CONCLUSION

In the framework of the Sustainable Development Goals, this paper provides empirical evidence about the evolution of environmental indicators.

More specifically, the analysis of a country database including SDG indicators confirms the existence of convergence, also detecting significant differences between countries.

These empirical findings suggest the need of fostering economic growth and the use of renewable energy in order to ensure access to affordable, reliable, sustainable and modern energy for all.

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