Sustainability as a Policy Tool

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Abstract

In this policy note we propose a new country-based sustainability index comprised of three main drivers: climate change, energy use, and resource depletion. We argue that increases in clean energy intensity (clean energy per dollar of GDP), decreases in carbon intensity (carbon emission per dollar of GDP), and water intensity (water used per dollar of GDP) significantly affect sustainability. Supplementary, we compare our proposed index with macroeconomic indicators like GDP, Income per capita and other development indices such as the Human Development Index and the GINI, showing marked differences, which we interpret as unexplored areas for sustainable gains.

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I. Introduction

Until recently, government policies have generally shied away from instruments designed to increase effective actions on the critical area of sustainability. Mostly, this is due to the misconception that the associated risks regarding potential impacts are low probable -*tail events*- coupled with a lack of quantifiable estimates. Furthermore, the concept of sustainability is generally too broad and difficult to materialize. For instance, to this date there is still little-to-none consensus as to which are the real drivers of sustainable growth and development.

Most industrialized and emerging countries alike pay lip service to the importance of sustainability without clear-cut implementation and verification guidelines. In most cases, the main challenge resides on their enforcement, especially in the absence of adequate and readily available metrics. Recently, however, during the aftermath of the Great Lockdown of 2020, there has been a sudden rise in environmental activism, demanding greater accountability in three main areas: climate change, energy transition (from fossil fuels to cleaner sources), and efficient use of critical resources that comply with social justice and equity principles.

Despite the divergent opinions, the last decade has seen a growing amount of evidence insisting that there are some (few) factors driving sustainability conditions and, therefore, exercising profound impact on the economy. For example, Hsiang et al. (2013) conclude that "*Mitigated climate warming is expected to reshape the global economy by reducing average global incomes roughly 23% by 2100 and widening global income inequality relative to scenarios without climate change*." Others point to climatic factors inducing changes in atmospheric composition as well as the way resources, like water and forest exploitation, affect societies and their economic activities (see Anthoff and Tol, 2014; Nordhaus and Moffat, 2017; and Nordhaus, 2019).

Unfortunately, assessment models and metrics have shown little effectiveness certifying the direction and magnitude of economic and environmental factors. Consequently, the need for a new metric-based approach to sustainability warrants a comprehensive index that combines aspects such as finite resources depletion and environmental protection. Paradoxically, most of the aggregate macroeconomic indicators used today do not include nor directly respond to sustainability improvements. For example, fiscal policies generally focus on social and economic indicators (e.g., employment, output, and debt) not directly associated to the physical and transition risks brought forth by climate change nor to the mix of energy sources. Moreover, any differential effect between

industrialized and emerging countries in response to climate factors has been largely overlooked.

In this policy note we propose a unified benchmark to measure both the size and composition of countries' sustainability in the context of climate change, energy use, and resource depletion. More specifically, in terms of composition, we use water stress (i.e. the ratio of water extraction to available water) and the share of renewable energies (as a share of each country's total energy). Additionally, we re-scale each country's contribution to climate change by using the per capita carbon emissions from fossil fuels. The resulting index, which we call *Sustainability for Economic Policy index,* hereinafter *S.E.P.,* will help identify how countries and regions perform and which factors contribute the most.

For comparability purposes, all variables were normalized to express standard deviations from the panel mean (across time and countries). We use a sufficiently broad time frame, from 1990 to 2017 and cover a total of 44 countries across 7 regions: Africa, Asia, Europe, Middles East, North America, South America, and Oceania. In total, the largest index value obtained (most sustainable country) was +2.0; and the lowest value obtained (most unsustainable country) was -2.2.

The interplay of the three index components: environmental, energy, and critical resources, also allows us to compare countries' (and regional) sustainability levels with macroeconomic variables and economic development indices. Also, economic efficiency estimates based on the three component factors shed considerable light into which corrective policies can be cost-effective.[1] In sum, the S.E.P. index globally describes each country's positive drive toward a clean energy transition plus the negative effect of carbon emissions and water scarcity on their sustainability. More importantly, it shows where there is room for improvement.

To date, quantifiable effects on sustainability have been few and far between. Furthermore, existing work generally focuses on isolated variables such as temperature, agriculture production, pollution, and critical demographic and urban growth parameters. Few efforts have been made to connect them jointly into a sustainability framework (Schlenker and Roberts 2009; and Graff Zivin and Neidell 2014). Also, while energy intensity is a common metric used to evaluate the

[1] The "efficiency" criteria, here also referred to as "intensity," denotes the amount of each factor component per unit of GDP. The evolution of the three intensity drivers (carbon intensity or carbon contained in every dollar of GDP, renewable energy intensity or clean energy contained in every dollar of GDP, and water intensity or water contained in every dollar of GDP) is also compared to the sustainability of every country and region.

efficiency of the energy sector in countries and regions, the other two variables that comprise our index (carbon and water intensities) are seldom mentioned in the literature. Thus, we believe that our work can be correlative to the small but growing strand of literature that advocates for empirical extensions of sustainability (Pindyck 2013; and Revesz et al. 2014).

We believe that the implications of our sustainability index and its regional or country-specific deconstruction are significant. Efforts towards energy transition (via reduction of fossil fuels), better resource distribution, and mitigation of carbon emissions can reshape and improve country, regional, and even global average incomes sustainably. This view contrasts with prior theories that saw climate change related actions as a burden to national and supranational endeavors (Anthoff D & Tol R, 2014; Delgado-Serrano M., Ramos P, & Lasso Zapata E, 2017). It envisages real potential gains in future economic policy in a manner not previously shown before, in the sustainability research literature.

II. A Sustainability Index

The Union of Concerned Scientists (UCSUSA) and the University of California Sustainable Agriculture Research and Education Program (SAREP) both express that a system approach "is essential to understanding sustainability." The *system approach* envisioned here incorporates the local ecosystem and communities affected in a broad and integrated way by ecological, economic, and social activities. They equally emphasize that such processes demand energy and water above all.

Accordingly, if a system approach is the most convenient, it requires analytical tools to explore the interconnections between its most critical aspects. In our case, the environmental sustainability metric development adheres to the following steps:

- Selection of key variables fulfilling the needs of all peoples and emphasizing an equal distribution of benefits as priority.
- The least number of explanatory (independent) variables that are clearly defined. In this sense, saturated models (with many input variables) will increase the analysis complexity while marginally informing about the processing cost. The few selected variables must each represent (i.e. be highly correlated) with several other variables omitted in the chosen system.

- The link between any and all consumption variables that affect sustainability are directly related to climate change and the depletion of critical resources.
- The design of a system approach must be based on the principle that avoiding the global greatest threat (i.e., CO_2 emissions) and promoting the greatest global benefit (i.e., conserving water) captures the lion's share in the promotion of a sustainable world.

II.A Motivation

Economic and social issues associated with agriculture, industry, energy, and domestic consumption cannot be separated from environmental factors. As barriers to sustainable and equitable economic systems arise, several problems emerge, including the following:

- Economic pressures have led to a significant loss of critical resources like water, particularly in emerging markets, while not finding the incentives to decrease fossil fuels in favor of clean energy sources.
- Aside from losing sustainability, a lack of policy support has contributed to the disintegration of rural communities and fragmentation of market systems (Hsiang and Jina 2014). Economically, it is exceedingly difficult for potential green investors to enter the market.

As such, climate related changes are increasingly (and negatively) affecting natural resources. Moreover, they are stressing non-traditional energy sources and critical resources like water. Based on the results obtained in Section III, we argue that while some of these effects are readily impacting industrial and agricultural activities, others undetected causes can have a permanent (undesirable) influence and permeate a wide range of sectors of any economy.

For policymakers, the challenge resides in reaching a compromise between conflictive aspects of economic output and green investment. The latter associated with what we denominate "vital resources", namely better critical resource management (like water) and curbing carbon emissions. Thus, hard-hit countries in these fronts are at higher sustainable risk but can also proportionally profit the most through targeting the weak links made visible by our proposed index measure. If so addressed, it will be in line with the U.N. Sustainable Development Goals.

II.B Method and Data Sources

This work compiles specific information by country and by year to establish a sustainability metric based on: (i) water scarcity, (ii) climate change and (iii) energy transition. In conducting our study, we match two sources of information for the three components used in the construction of the S.E.P. Variable descriptions and sources are found in Table 1 of Appendix B.

To compare all variables under a common metric, the three components described above were standardized so that each reading corresponds to the number of standard deviations from the mean. The S.E.P. is calculated maintaining the same relative weight for each component. It is represented by the following equation:

$$S.E.P. = Energy\ Transition - [Climate\ Change + Water\ Scarcity] \quad (1)$$

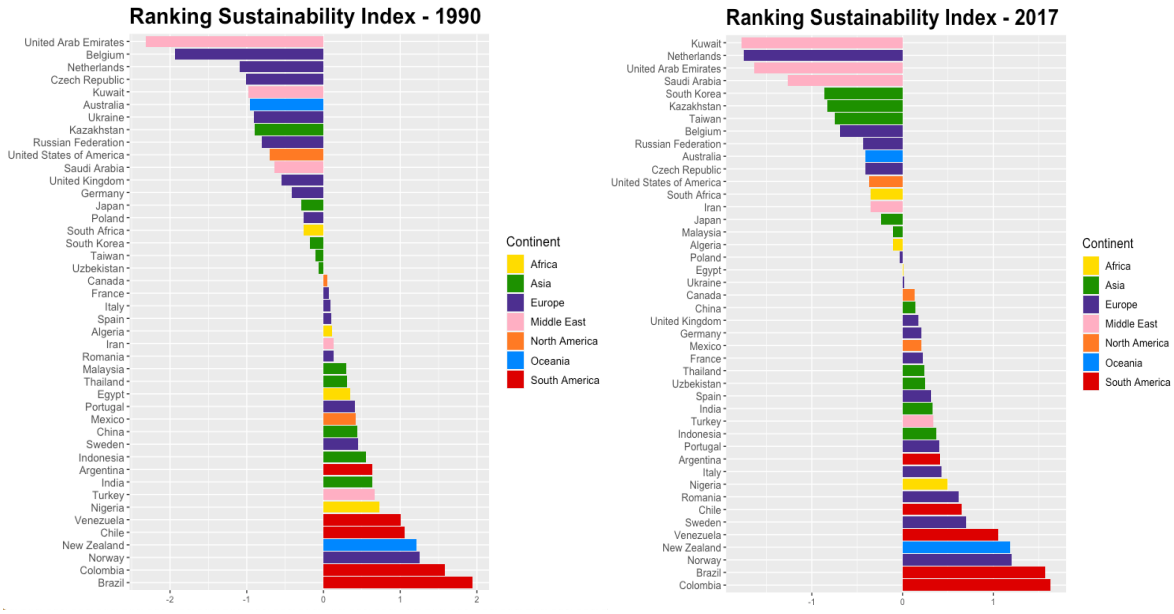
where energy transition captures the share of renewable energies in the production of electricity (Source: Enerdata). The variable for water scarcity was measured as the ratio of total water extraction to total usable water (Source: Food and Agriculture Organization of the United Nations, FAO). And climate change captures the magnitude of total carbon emissions from fuel combustion (Source: Enerdata).

Hence, the S.E.P. reflects the positive effect of clean energy efforts to offset the negative impacts of carbon emissions and water scarcity. Put differently, it rewards the use of renewable energies while penalizing both carbon emissions and water stress. In that respect, it complies with the basic universally accepted requirement of the sustainability condition: *to mirror the ability of countries to meet their current needs without further compromising the ability of future generations to meet theirs*. The S.E.P. index was computed for each year between 1977 and 2019, for 44 countries.

II.C Descriptive Statistics

As already stated, the S.E.P. compares the overall effect of carbon emissions, critical resources exploitation and efforts to generate clean energy for the economy between countries and regions. As Figure 1 shows, for two years close to the extreme points of our data time-series (1977-2020), countries and regions are ranked –in ascending order-- according to the combined criteria based on how their environmental, critical natural resources, and energy transition conditions influence their evolving sustainability.

Figure 1. The S.E.P. for 44 countries and 7 regions, 1990 & 2017



* S.E.P. Index in ascending order (more sustainably at the bottom)

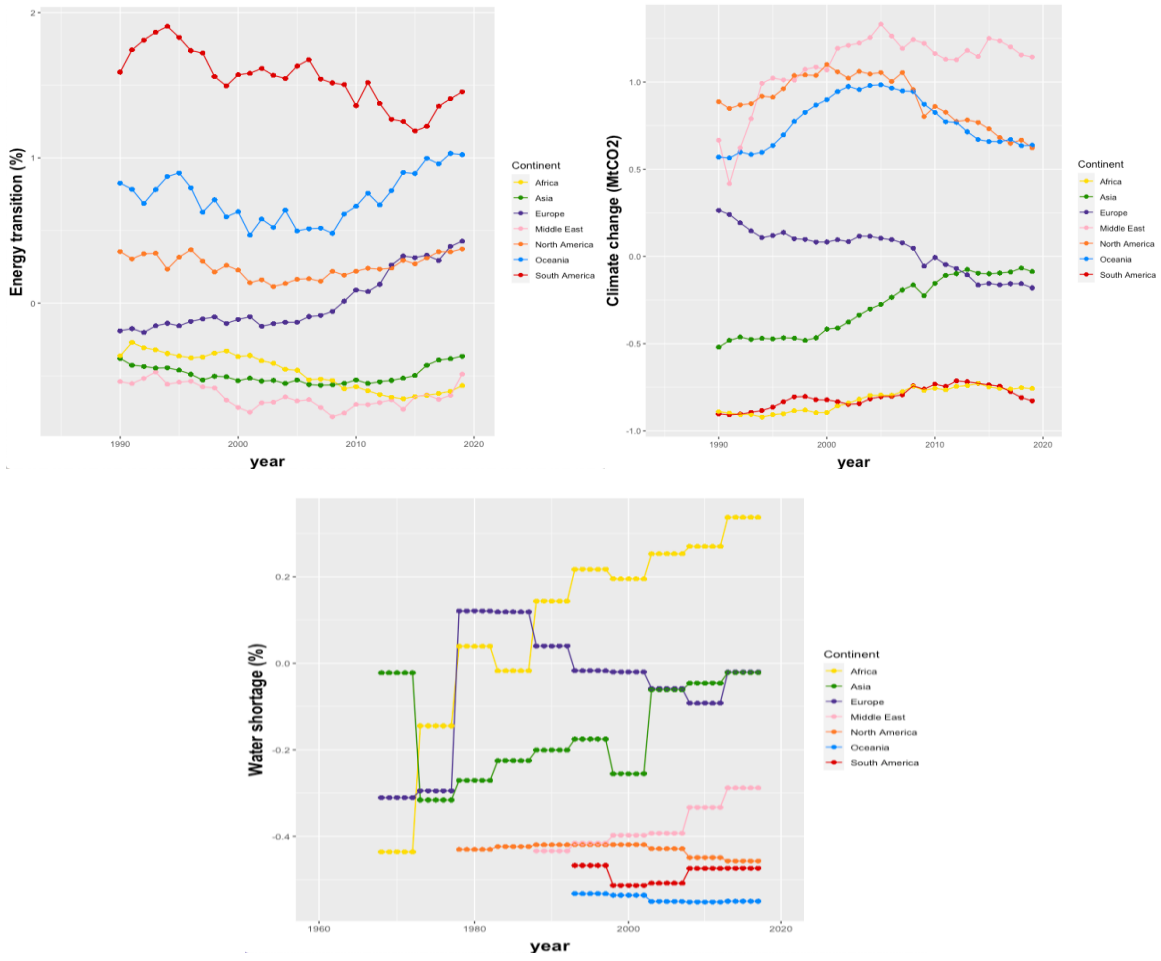
III. Summary of Results & Other Related Graphic Associations

In what follows we can see the anatomy of interactions and magnitude of the S.E.P., its evolution though time (along with its 3 factor components) by country (44) and by region (7). We also show the interaction between each component and the overall S.E.P. Namely, we capture the different ways each country and region determine the association of factors included in equation (1); the results point towards the type of corrective policies that nations and even regions can undertake to improve their sustainability pathway. We also confront the overall S.E.P. and its components with each country's GDP. Finally, we show visual correlations between S.E.P. and other widely used indices like the HDI, Gini and WHI (here called "alternative" indices as defined in Appendix C) and with the "intensity indicators' already defined (footnote 1). Below the corresponding graphs:

III.A S.E.P Components vs Time

The evolution of the three components of the S.E.P index is depicted in Figure 2 and provides a heuristic reading of how the 7 world regions (see Appendix D) have behaved in the past and their current status. Ideally, countries would want to score high in clean energy transition (left graph) and low in carbon emissions (right graph) as well as in water shortage (bottom graph). Note that both South America and Oceania are on top (high on clean energy and low in water shortage). However, in terms of lowest carbon emissions, South America and Africa positively outperform all others.

Figure 2. The three S.E.P. components across time



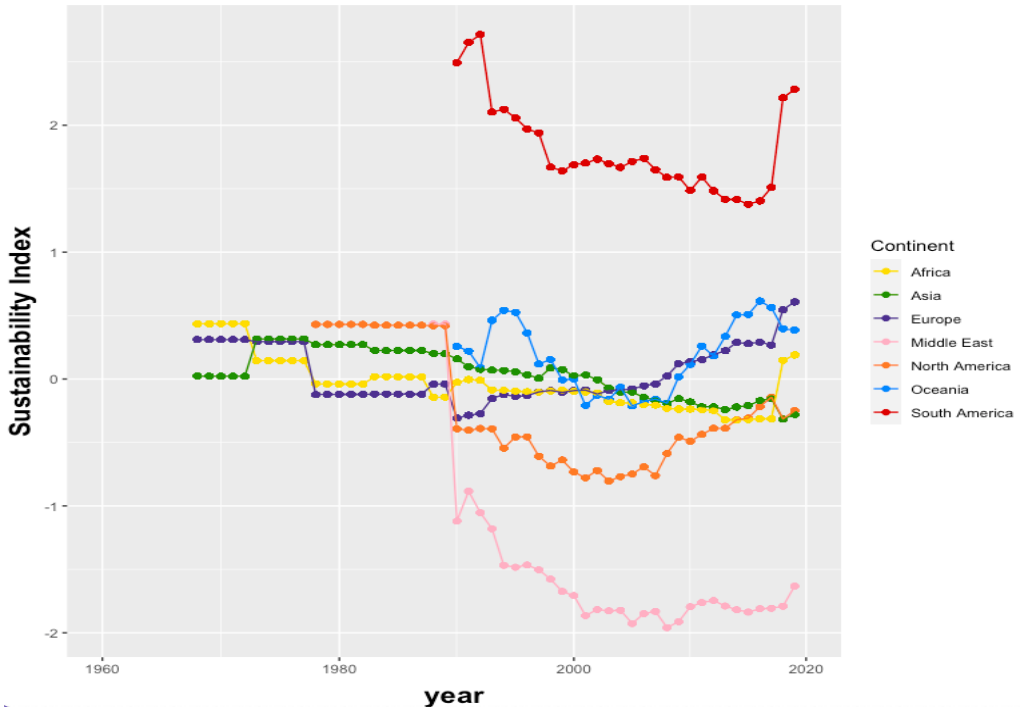
Conversely, at the bottom of the three scales (low clean energy, high carbon emissions and high-water shortages), the Middle East and Asia reign. Africa shows low clean energy and increasing levels of water stress. Interestingly, in the mid-

section, the EU and the US share opposing trends. That is, both the EU and the U.S. have increased clean energy, but the EU is much more effective in lowering carbon emissions than the US. The US increasing clean energy is not enough to cancel out its increasing carbon emissions.

III.B S.E.P. index vs Time

As observed by Figure 3, the S.E.P. index shows that South America is the best performer, while the Middle East ranks worst. Interestingly, both of these regions had their sustainability peaks at around 1990 and by 2020 their levels are lower than their peak levels. At the same time, middle-of-the-road sustainability regions, show divergent evolutionary paths: The EU slightly improving from the 1970s levels while North America (namely the U.S.) declining over the period to 2020. Both Asia and Africa have remained relatively stable.

Figure 3. The S.E.P. index across time

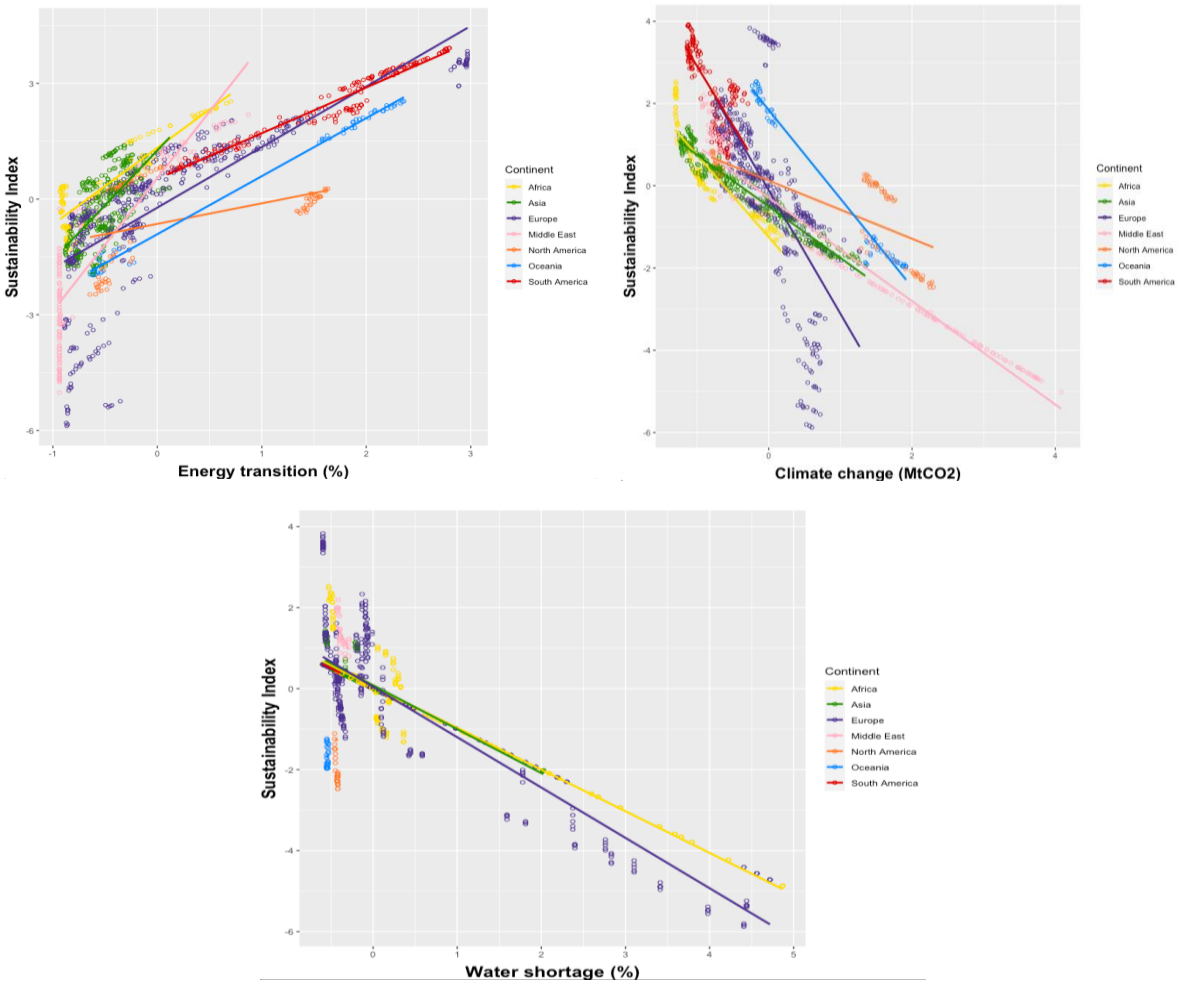


III.C The S.E.P components vs S.E.P.

Figure 4 shows the marked heterogeneity across regions between each individual index component and the S.E.P. As observed, the greatest country gains in clean energy transition are in Asia, Africa, and the Middle East. The EU follows behind and then South America. The U.S. lags behind.

In terms of lowering carbon emissions, the EU and South America are highest in the ranks. Oceania follows, then Africa and then Asia. The lowest grade score is attained by North America. Finally, regarding water availability (no water shortage) South America, Africa and Asia lead the ranks. The EU follows and then North America and Oceania. The Middle East is last in this component.

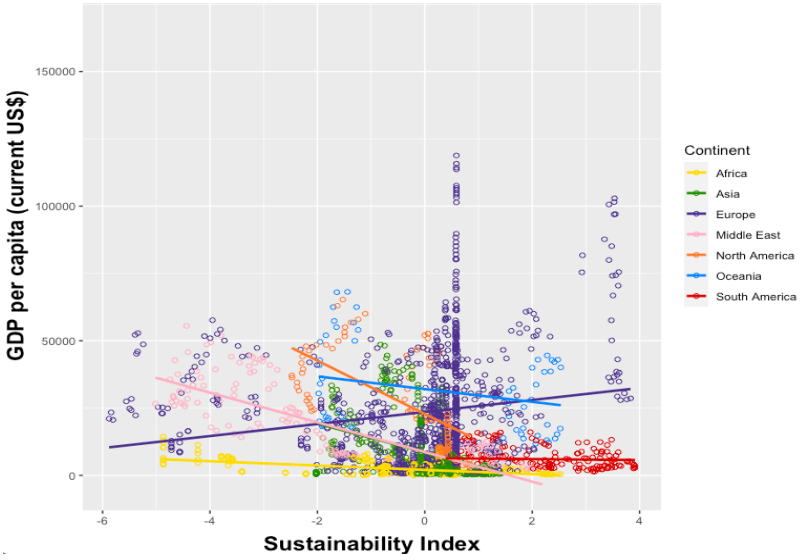
Figure 4. Individual components vs the S.E.P. index



III.D S.E.P. index vs GDP per capita

Figure 5 shows the differences of the S.E.P. index compared to GDP per capita. As shown, only the European countries included in our sample show a positive correlation between sustainability and income per capita. All others reflect (the somewhat expected) decreasing levels of S.E.P. as incomes increase; North America showing the most pronounced inverse relationship geographically. We believe this to be an important issue because, it in part reflects the inverse relationship between GDP per Capita and CO2 emissions.

Figure 5. The S.E.P. index vs GDP per capita



Intuitively, emerging countries usually begin with a high sustainability measure driven mostly by low CO2 emissions. They later move towards higher CO2 and higher GDP per capita which worsens their sustainability indicators. Once countries climb the latter to an industrialized status, then and only then do they observe a gain in sustainability, as they start to invest in greener energy.

As an example, Figure 6 shows the world's population arranged in ventiles by income, between 1990 and 2015. Notice that 37% of all carbon emissions were produced by the richest 5% and 50% by the richest 10% (the top two ventiles). The impact of the poorest half (the bottom ten ventiles) of the world's population was practically negligible. That motivated the SEI (Stockholm Environment Institute) to call such distribution "*the carbon inequality dinosaur*".

Figure 6. Share (%) of growth in CO2 emissions by income

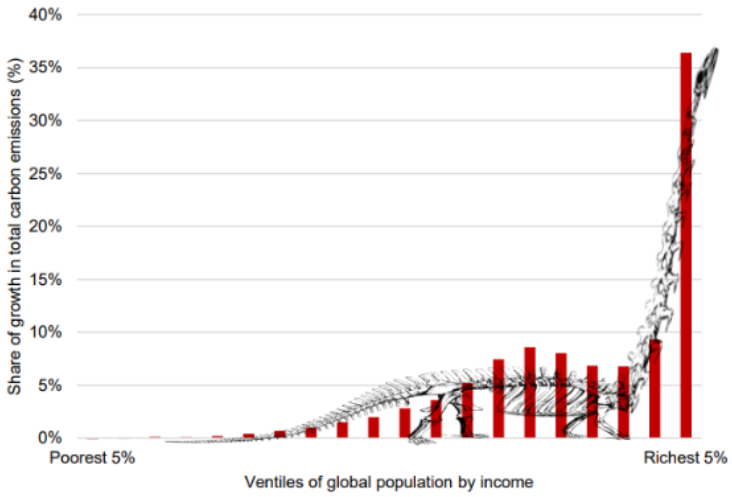


Figure taken from the Stockholm Environment Institute

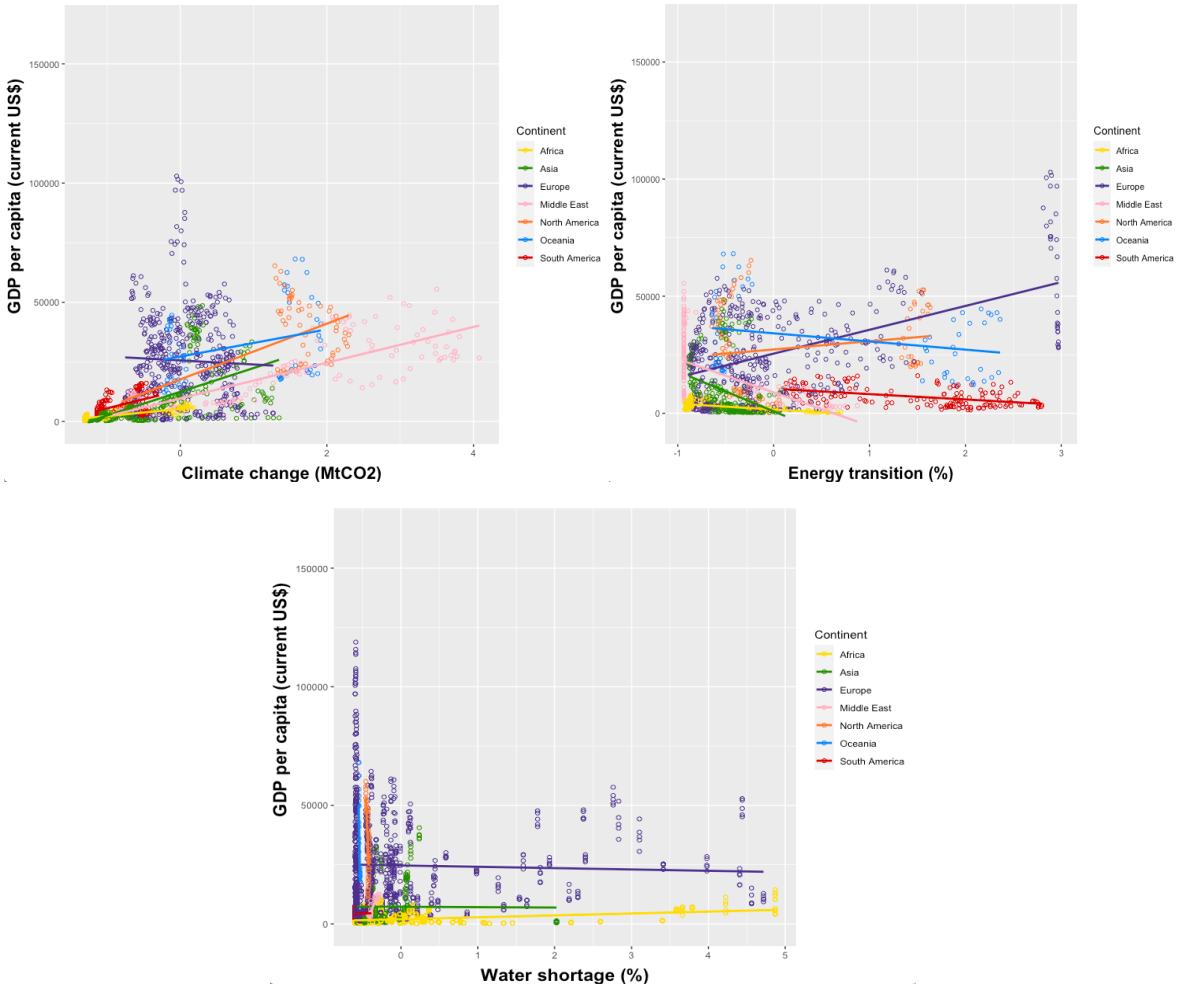
III.E S.E.P. components vs GDP per capita

We next show the S.E.P. components as a function of income per capita. As already shown in the previous subsection, most of the world walks in a more unsustainable path as countries get more industrialized (higher GDP per capita). But in terms of the relationship between income per capita and carbon emissions, Figure 7 shows that North America, Asia, and Middle East exhibit the strongest correlation.

The income effect of clean energy is strongest in Europe and somehow positive but weaker in North America. In all other regions, including South America, (a region that ranks highly in sustainability), the energy transition to clean sources does not compensate the negative effects of fossil fuels.

Also, except in the Middle East and Oceania, water shortage is basically inelastic to income per capita.

Figure 7. S.E.P. components vs GDP per capita

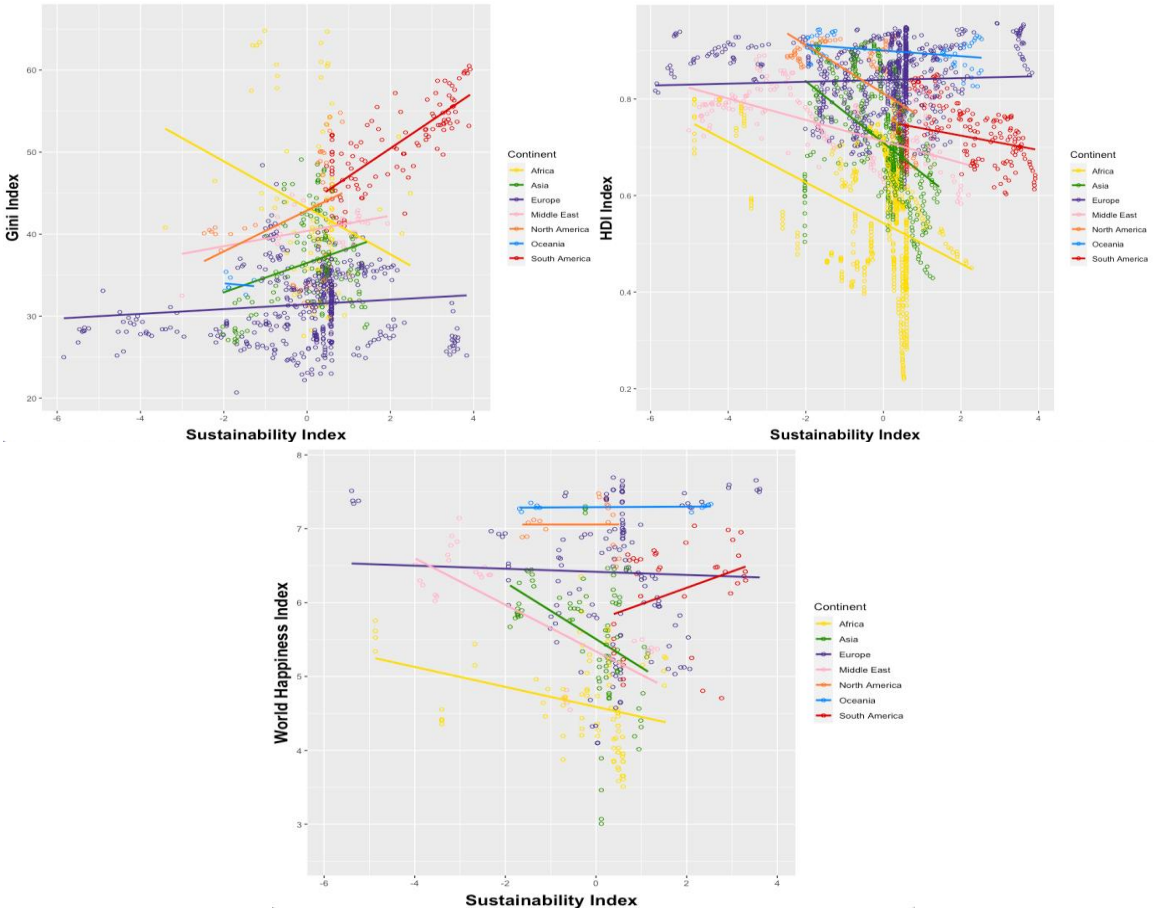


III.F S.E.P. vs Other Indices

Figure 8 presents the correlation between the S.E.P and three alternative indices: the Gini Index, the Human Development Index, and the World Happiness Index (all defined in Appendix C). In principle, more inequality in a region or country (higher GINI) should corresponds with larger deviations in sustainability (S.E.P.). This, in fact applies to all regions (more pronounced in the Americas) except in Europe and Africa. Hence, wealth redistribution will have a much lower impact on sustainability in the latter two regions.

Europe clearly shows the positive effect on sustainability from higher deviations of HDI (education, life expectancy, and income) while all other regions show a negative relationship. By taking the UN's HDI as a proxy for general welfare, the S.E.P. reacts to it in a similar fashion as GDP per capita (see Section III.D).

Figure 8. The S.E.P. index vs other indices (HDI and WHI)



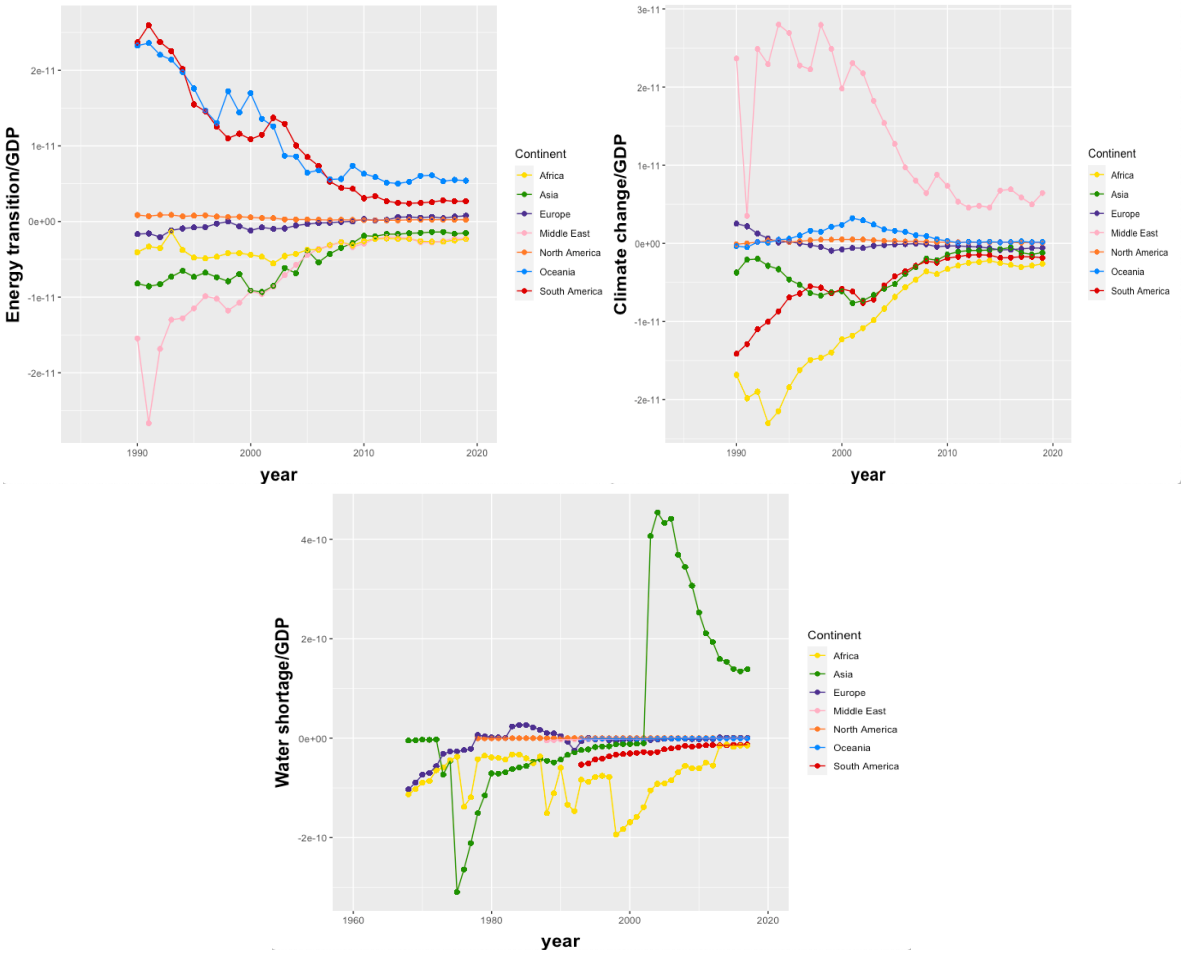
III.G S.E.P. vs Intensity Metrics

Metrics of "intensities" are becoming more relevant in the literature. They can be used to capture the evolution of the amount of an input (energy, carbon, water) that goes into the production of one dollar of GDP. Appendix E illustrates world energy and carbon intensities maps along with global and per-capita carbon emissions.

Figure 9 shows how clean energy intensity, climate change (CO_2) intensity and water intensity have evolved since 1990. South America and Oceania have been decreasing the amount on clean (renewable) energy used in their productive processes; either because they are using more fossil fuels or due to more efficient use of their -mostly- hydro energy systems. All other regions are using more clean energies, but their effect on sustainability is far larger for the Middle East, Asia, and Africa, and relatively small for Europe and North America.

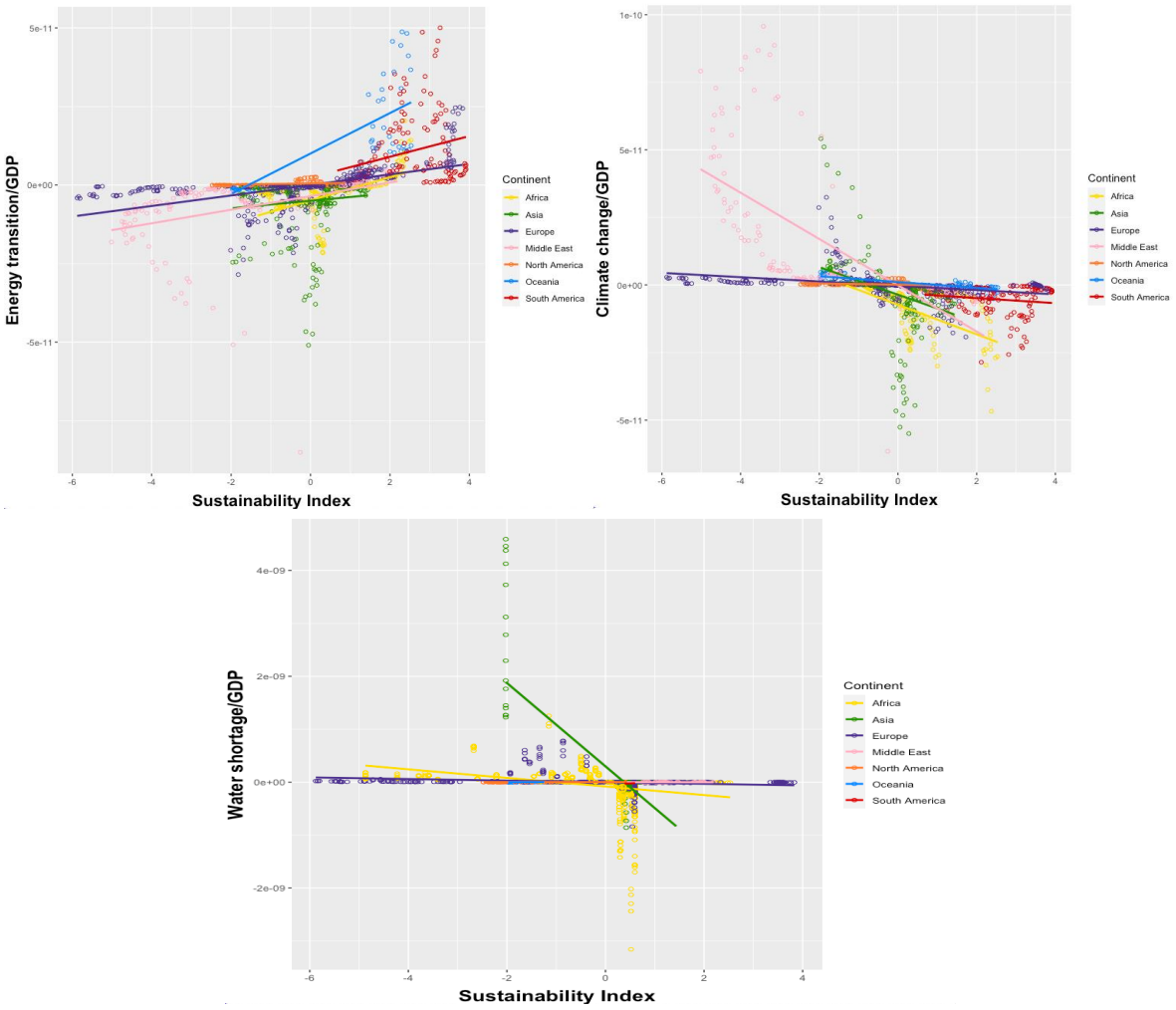
Africa, South America, and Asia are increasing the amount of CO2 per dollar produced while the Middle East shows a decreasing trend. In turn, Europe, North America, and Oceania show almost no variation through time. Water use per unit of GDP has been increasing in Africa and South America. Although it has also increased in Asia up to the year 2005, it has been rapidly decreasing ever since.

Figure 9. Intensity metrics across time



The three "intensity" graphs of Figure 10 confirm that negative deviations of energy intensity are positively correlated to sustainability, while positive deviations of carbon and water intensities are negatively correlated to sustainability. Oceania and South America have the most pronounced effect as far as clean energy intensity is concerned. The Middle East and Africa and The Middle East and Asia impact their sustainability more by the high use of fossil fuels (abundant) and water (scarcity) in their system approach to their national production infrastructure.

Figure 10. The S.E.P index vs Intensity metrics



IV. Concluding Remarks.

Our sustainability policy approach through a *Sustainability for Economic Policy index (S.E.P)* requires targeting three pillars: economic, social, and environmental, to incorporate the following aspects in the analysis:

- The stock and flow of fundamental resources such as water and energy.
- The levels of their associated scarcity, i.e., to minimize the impact of inputs that affect climate change like high consumption of fossil fuels or relatively low levels of renewable energy and water access.

A practical take-away of our analysis is summarized by the way the S.E.P. index reflects the interaction of several selected "welfare indices" and "intensity" indicators. A clear advantage of our proposed S.E.P. index is the ability to represent,

in a simple, practical, and concise way, the complex environment-water-energy nexus.

Mancur Olson's classic analysis of collective action explains that positive social changes may not happen even if the benefits are widespread, but the costs are concentrated. Namely because the cost-assuming groups can block the change. One could, by the same logic, point to an opposite solution, where rich countries finance poor countries' carbon transition. Indeed, the G7 summit reiterated its "commitment" to the $100bn annual climate financing scheme made at Copenhagen a decade ago. Within countries, a fair transition (energy, carbon, water and social) might entail taxation and carbon dividend policies. The latter raises the price of emissions and redistribute the revenue on a lump sum basis to the population and redistributes water availability. Achieving this, in turn, depends on getting targeted financial policies.

While more clean energy will mitigate carbon emissions, we note that access to water is still one of the greatest risks to global prosperity. Policymakers face multiple challenges regarding water management and must grapple with both an uncertain future and competing interests, while also ensuring there is enough water for people, cities, agriculture, energy, and ecosystems. To date, we believe that both water and carbon emissions are unevenly skewed among income groups.

Central to whether economic policy can be effective in the area of sustainability is the issue of "market neutrality." A conventional principle for economic orthodoxy that argues *economic policy* (whether fiscal or monetary) *should not interfere with an efficient allocation of capital or resources*. But when most countries face such ample degree of sustainability and markets are deeply distorted in energy, ecology, and the environment (resulting from underpriced carbon emissions, unevenly priced energy sources and acute maldistribution of water) there cannot be neutrality, while lack of policy action can only reinforce distortions.

This does not mean that only governments should act alone. In fact, much of the innovation to increase sustainability can be provided by the private sector. For example, government investment will encourage private investors to put more of their money into green tech. Stock markets have proven to be much better at funding green technological innovation than banks. For a bank-heavy region such as the Eurozone, that could be an important avenue to raise capital through carbon, water, and clean energy. If countries (and supranational institutions) target net-zero carbon and greater resource distribution, they must also enact regional and intra-regional policies for market induced sustainability.

Appendix A: The S.E.P. index by country for "extreme" years: 1990 and 2017

S.E.P. index for 1990

Rank	Country	Continent	Energy transition	Climate change	Water shortage	Sustainability Index
1	United Arab Emirates	Middle East	-0.94	3.69		-2.32
2	Belgium	Europe	-0.87	0.53	4.41	-1.94
3	Netherlands	Europe	-0.89	0.57	1.81	-1.09
4	Czech Republic	Europe	-0.85	1.17		-1.01
5	Kuwait	Middle East	-0.94	1.01		-0.98
6	Australia	Oceania	-0.54	1.37		-0.96
7	Ukraine	Europe	-0.80	1.02		-0.91
8	Kazakhstan	Asia	-0.61	1.20		-0.90
9	Russian Federation	Europe	-0.34	1.27		-0.80
10	United States of America	North America	-0.47	2.06	-0.42	-0.70
11	Saudi Arabia	Middle East	-0.94	0.34		-0.64
12	United Kingdom	Europe	-0.84	0.37	0.43	-0.54
13	Germany	Europe	-0.78	0.78	-0.33	-0.41
14	Japan	Asia	-0.45	0.12		-0.29
15	Poland	Europe	-0.84	0.30	-0.36	-0.26
16	South Africa	Africa	-0.87	-0.15	0.05	-0.26
17	South Korea	Asia	-0.70	-0.35		-0.17
18	Taiwan	Asia	-0.58	-0.36		-0.11
19	Uzbekistan	Asia	-0.47	-0.35		-0.06
20	Canada	North America	1.51	1.40		0.05
21	France	Europe	-0.38	-0.22	-0.37	0.07
22	Italy	Europe	-0.24	-0.12	-0.40	0.09
23	Spain	Europe	-0.25	-0.43	-0.13	0.11
24	Algeria	Africa	-0.91	-1.00	-0.24	0.11
25	Iran	Middle East	-0.53	-0.79		0.13
26	Romania	Europe	-0.24	-0.13	-0.50	0.13
27	Malaysia	Asia	-0.26	-0.86		0.30
28	Thailand	Asia	-0.50	-1.11		0.31
29	Egypt	Africa	-0.02	-1.11	0.05	0.35
30	Portugal	Europe	0.44	-0.65	-0.14	0.41
31	Mexico	North America	0.03	-0.80		0.42
32	China	Asia	-0.14	-1.02		0.44
33	Sweden	Europe	1.07	-0.27	-0.01	0.45
34	Indonesia	Asia	-0.12	-1.22		0.55
35	Argentina	South America	0.46	-0.81		0.64
36	India	Asia	0.02	-1.25		0.64
37	Turkey	Middle East	0.64	-0.92	-0.43	0.67
38	Nigeria	Africa	0.34	-1.31	-0.53	0.72
39	Venezuela	South America	1.50	-0.52		1.01
40	Chile	South America	1.17	-0.95		1.06
41	New Zealand	Oceania	2.19	-0.23		1.21
42	Norway	Europe	2.97	-0.20	-0.60	1.25
43	Colombia	South America	2.05	-1.11		1.58
44	Brazil	South America	2.76	-1.13		1.95

S.E.P. index for 2017

Rank	Country	Continent	Energy transition	Climate change	Water shortage	Sustainability Index
1	Kuwait	Middle East	-0.94	2.61		-1.77
2	Netherlands	Europe	-0.35	0.45	4.44	-1.75
3	United Arab Emirates	Middle East	-0.91	2.36		-1.64
4	Saudi Arabia	Middle East	-0.93	1.59		-1.26
5	South Korea	Asia	-0.78	0.95		-0.86
6	Kazakhstan	Asia	-0.49	1.17		-0.83
7	Taiwan	Asia	-0.73	0.77		-0.75
8	Belgium	Europe	-0.17	0.12	1.78	-0.69
9	Russian Federation	Europe	-0.26	0.61		-0.43
10	Australia	Oceania	-0.32	1.47	-0.55	-0.41
11	Czech Republic	Europe	-0.45	0.37		-0.41
12	United States of America	North America	-0.26	1.31	-0.46	-0.37
13	South Africa	Africa	-0.72	-0.02	0.36	-0.35
14	Iran	Middle East	-0.74	-0.04		-0.35
15	Japan	Asia	-0.29	0.19		-0.24
16	Malaysia	Asia	-0.28	-0.06		-0.11
17	Algeria	Africa	-0.91	-0.78	0.19	-0.10
18	Poland	Europe	-0.37	0.13	-0.42	-0.03
19	Egypt	Africa	-0.60	-0.96	0.33	0.01
20	Ukraine	Europe	-0.62	-0.66		0.02
21	Canada	North America	1.63	1.36		0.13
22	China	Asia	0.06	-0.21		0.14
23	United Kingdom	Europe	0.25	-0.39	0.11	0.17
24	Germany	Europe	0.39	0.24	-0.46	0.20
25	Mexico	North America	-0.31	-0.72		0.21
26	France	Europe	-0.26	-0.48	-0.44	0.22
27	Thailand	Asia	-0.29	-0.69	-0.33	0.24
28	Uzbekistan	Asia	-0.40	-0.90		0.25
29	Spain	Europe	0.35	-0.38	-0.20	0.31
30	India	Asia	-0.26	-1.07	-0.19	0.33
31	Turkey	Middle East	0.21	-0.52	-0.29	0.34
32	Indonesia	Asia	-0.45	-1.02	-0.55	0.37
33	Portugal	Europe	0.66	-0.47	-0.09	0.41
34	Argentina	South America	0.22	-0.61		0.41
35	Italy	Europe	0.46	-0.40	-0.44	0.43
36	Nigeria	Africa	-0.26	-1.28	-0.48	0.50
37	Romania	Europe	0.56	-0.72	-0.57	0.62
38	Chile	South America	0.78	-0.53		0.65
39	Sweden	Europe	1.33	-0.65	-0.13	0.70
40	Venezuela	South America	1.44	-0.67		1.06
41	New Zealand	Oceania	2.24	-0.13		1.18
42	Norway	Europe	2.89	-0.12	-0.60	1.20
43	Brazil	South America	2.16	-0.99		1.57
44	Colombia	South America	2.18	-1.09		1.63

Appendix B: Variables and sources used in the construction of the S.E.P. index

Variable	*Description*	*Source*	*Time Period*
Water Withdrawals	Amount of water extracted each year for agricultural, industrial and municipal uses.	FAO	1972-2017
Total available hydro (fresh water) resources.	Total exploitable water resources are sought by countries for their economic and environmental purposes by using river flows, storing flood water through dams, extracting groundwater, and de-salt water processes from the oceans.	FAO	1962-2017
Fossil fuels carbon emissions	CO2 emissions cover emissions from the combustion of fossil fuels (coal, oil and gas) by sector. They are calculated according to the UNFCCC methodology (according to the 2006 IPCC Guidelines for National Greenhouse Gas inventories).	Enerdata	1990-2019
Renewable energy participation in the production of electricity	Enerdata offers a relationship between electricity production from renewable energies (hydro, wind, geothermal and solar) and total electricity production.	Enerdata	1990-2019

Appendix C: Definition of Alternative Indices

- *The Human Development Index* (HDI) is a statistic developed and compiled by the United Nations to measure and various countries' levels of social and economic development. It is composed of four principal areas of interest: mean years of schooling expected years of schooling, life expectancy at birth, and gross national income per capita.

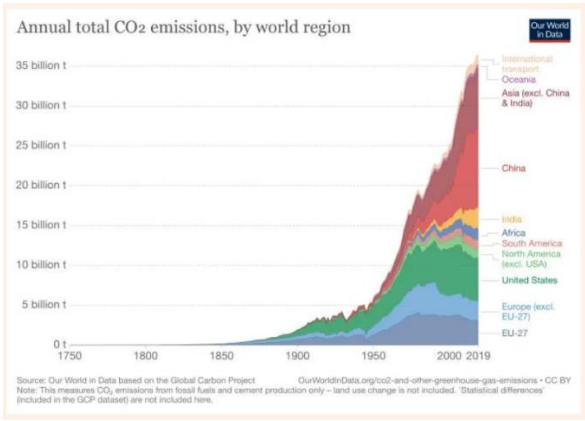
- *The Gini index*, or Gini coefficient, is a gauge of economic inequality, measuring income distribution or, less commonly, wealth distribution among a population.

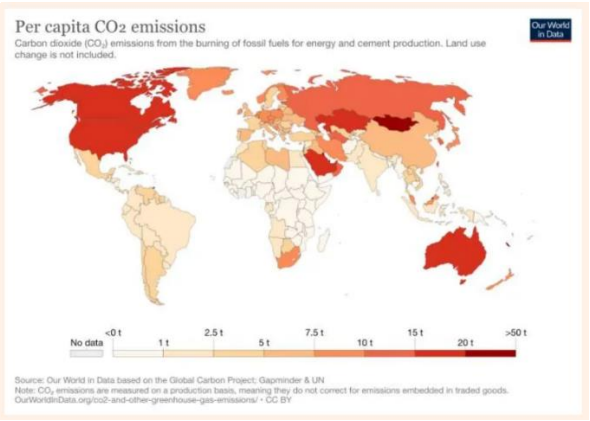
- The World Happiness Index (WHI) and Report is the result of a landmark survey by the U N Sustainable Dev Goals to assess the state of global happiness ranking 156 countries by how happy their citizens are in cities around the world. The index shows how the social, urban, and natural environments combine to affect a country's happiness.

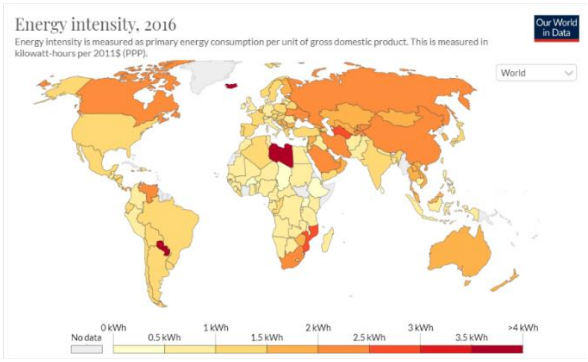
Appendix D: Definition of Regions and their selected countries

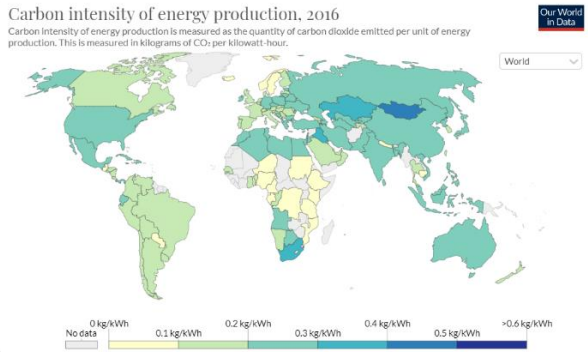
REGION	COUNTRY
AFRICA	South Africa
	Algeria
	Egypt
	Nigeria
ASIA	Kazakhstan
	Japan
	South Korea
	Taiwan
	Uzbekistan
	Malaysia
	Thailand
	China
	Indonesia
	India
EUROPE	Belgium
	Netherlands
	Czech Republic
	Ukraine
	Russian Federation
	United Kingdom
	Germany
	Poland
	France
	Italy
	Spain
	Romania
	Portugal
	Sweden
	Norway
MIDDLE EAST	United Arab Emirates
	Kuwait
	Saudi Arabia
	Iran
	Turkey
NORTH AMERICA	United States of America
	Canada
	Mexico
OCEANIA	Australia
	New Zealand
SOUTH AMERICA	Argentina
	Venezuela
	Chile
	Colombia
	Brazil

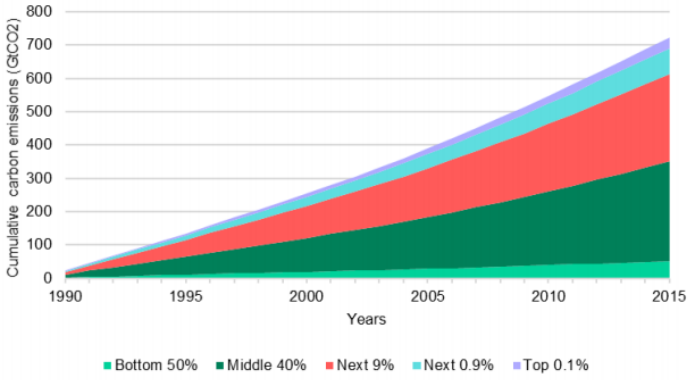
Appendix E: Figures taken from "Our World in Data"











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