Sustainability and Goal Fitness Index for the Analysis of Sustainable Development Goals: A Methodological Proposal

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Abstract: The Sustainable Development Goals (SDGs) were adopted in September 2015 by the 193 member states of the United Nations (UN), which include 17 goals, 169 targets and 244 indicators, as an attempt to radically change the approach of the Sustainable Development Goals. Millennium Development (MDG). Since the adoption of the 2030 Agenda, the scientific community has increased its interest in the evaluation, analysis, and evaluation of the interrelationships between the SDGs, proposing different approaches and using a diversity of methodological tools for the interactions of the SDGs. This research proposes a methodology that takes advantage of the concepts of Economic Fitness for the creation of a Sustainability Fitness Index (SFI) for the countries and a Goal Fitness Index (GFI) for each SDG. These indices are intended to provide a tool to analyze the interrelationships between the Sustainable Development Goals in such a way that they offer a new approach to address the capacities of the countries and the fulfillment of the SDGs. The results of the SFI are a first attempt to identify development priorities aligned with the SDGs in each country, based on their available productive capacities, which could help make more efficient use of their limited resources and increase the achievement of the SDGs.

1 INTRODUCTION

The 2030 Agenda represents a new era in the worldwide challenge of achieving some of the most ambitious objectives for the humanity, setting a "plan of action for people, planet and prosperity" that must be achieved within 15 years (2015-2030) (UN, 2015).

In this pathway towards sustainability, the countries have experienced several implementation challenges, including limited resources (economic, human, infrastructure, etc.), highly complex network of interactions between SDGs, and lack of alignment between national development plans and the 2030 Agenda. (Lack of policy coherence; policy vs politics).

In the last few years, the countries have sent their Voluntary National Reviews (VNRs) to the High-Level Political Forum on Sustainable Development of the United Nations, sharing their experiences and results in the implementation of the SDGs at the national level (UN, 2016). The learnings from these experiences have enhanced the importance of improving the understanding of the nature and impact of the interlinkages between the different SDGs at the national level, considering their universal and integrated design.

As many experts have underlined, in this global scenario and facing the complexity and universality of the SDGs, a priority setting for the implementation of the 2030 Agenda is recommended (Pereira et al, 2021; Allen et al., 2018; Allen et al., 2018a; Weitz et al., 2018; Zelinka & Amadei, 2019; McGowan et al., 2018), in order to: improve the qualitative and quantitative understanding on SDGs interactions; identify direct and indirect effects of SDGs interactions; detect patterns on SDGs interactions; identify critical goals and targets (central nodes) in

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the SDG network; and secondary analyses to increase synergies and avoid trade-off in the implementation of the 2030 Agenda.

This work follows the ideas presented in (Pereira et al., 2021) who presented a paper that studies the interactions between countries and their compliance with the SDGs from the point of view of complex systems, based mainly on the theory of economic complexity proposed by (Haussman et al., 2014).

The aim of this study is to propose a new methodological approach for the analysis of the SDG interlinkages and the progress of the countries in the implementation of the 2030 Agenda, based on their accumulated sustainability capabilities measured using economic fitness and network theory (Tacchella et al., 2012; Cristelli et al., 2013; Tacchella et al., 2013; Pugliese, Zaccaria & Pietronero., 2016).

This paper is organized as follow: first, in Section II a brief account of state-of-the-art literature on Sustainable Development Goals (SDGs) and SDG interlinkages analysis from the point of view of Economic Fitness is made. Then, in Section III the methodology, based on the economic fitness (from the point of view of complexity analysis) to evaluate the SDG interlinkages is explained. Third, in Section IV, we show the results and discussion of our analyses, including the interpretation of the findings.

Finally, in Section V, the conclusions are presented.

2 LITERATURE REVIEW

The UN Sustainable Development Goals (SDGs), adopted in September 2015 in the document called "*Transforming our world: the 2030 Agenda for Sustainable Development*" set the structure of the SDGs, including its 17 goals, 169 targets and 244 indicators, as an attempt to change the approach from the top-down agenda of the Millenium Development Goals (MDGs) to the bottom-up agenda of the SDGs. This new approach should improve the adoption of the "indivisible and integrated" 2030 Agenda, focusing on the 3 dimensions of the sustainable development: social, economic, and environmental (UN, 2015).

As mentioned before, the scarcity of resources is one of the main challenges that the countries must face in their way towards sustainability. In this context, and according to (UNCTAD, 2014), achieving the 2030 Agenda will require not only political commitment, but also important global investments of approximately 5-7 trillion USD per year (2015-2030), which already presents important gaps.

Then, from the perspective of the complexity of the interactions in the SDG`s network, the evidence from the VNRs reveal the need of improving the understanding of the interlinkages between goals, targets, and indicators in the system, to take advantage of the synergies and to improve policy coherence and alignment with the national development plans (UN, 2016; Allen et al., 2018; Allen et al., 2018a; Weitz et al., 2018; Pereira et al. 2021).

2.1 The Design & Nature of the SDGs

Since 2016 the scientific community has increased its interest in the assessment, analysis, and evaluations of the interlinkages between the SDGs, proposing different approaches and using a diversity of methodological tools for SDG interactions. Moreover, the analysis of SDG interlinkages offers fundamental information for policymakers, guiding the decision-making and the policy-design, to balance the different interests of the country (social, economic, or environmental).

In this context, the authors have begun to focus the analysis in the progress of countries in the accomplishment of the SDGs, through rankings (by goals, targets or indicators), qualitative methodologies, traffic light approaches, and many others (Griggs et al., 2017; ICSU, ISSC, 2015; Sachs et al., 2018; Schmidt-Traub et al., 2017; Salvia et al., 2019), in order to identify critical goals and targets for the sustainable development of the countries.

Nowadays, the report made by (Sachs et al., 2018) and published annually since 2016 with Bertelsmann Stiftung and the Sustainable Development Solutions Network (SDSN), is the reference for evaluating the progress of countries towards sustainable development.

The analysis and evaluation of the SDGs is a very complex task, as it has been already underlined in several studies (Dargin et al., 2019; Karnib, 2017; McCollum, et al., 2018), therefore, new methodologies have been proposed in the last years to improve our understanding.

In the beginning, the literature on the SDG interlinkages focused on the study of one-on-one impact, evaluating the interaction of an SDG with another goal or development priority (Vladimorova & Le Blanc, 2016, Alcamo, 2019; Nerini et al., 2017; Maes et al., 2019).

More recently, the scope has been expanded to the analysis of the interactions between a set of goals, in

an approach known as the "nexus approach". Then, several studies propose different "nexus" and combinations of set of goals, as for example: water-energy-food nexus, energy-poverty-climate nexus, etc. (Liu et al, 2018; Bleischwitz et al, 2018; Dargin et al., 2019; Karnib, 2017).

As mentioned by (Liu et al., 2018), the nexus approach facilitates the identification of synergies between goals, the improvement of policy design and the implementation of policies. Moreover, the nexus approach reduces the "*silo-thinking*" to focus on the synergies of critical resources and the promotion of wellbeing (Liu et al., 2018; Bleischwitz et al., 2018; Dargin et al., 2019; Karnib, 2017).

Authors using the nexus approach underline that focusing only on the type of interaction is not enough, and it must also be considered an impact analysis (direct or indirect) of the interactions (Karnib, 2017).

Recent studies have incorporated semi-quantitative methodologies with the purpose of improving the comprehension of the interactions (synergies and trade-off) in the intricate and complex SDG network, offering a new perspective in the analysis and visualization of the different interactions (i.e. network analysis) (Allen et al, 2018; Allen et al, 2018a; Weitz et al., 2018; Zelinka & Amadei, 2019; McGowan et al, 2018; Lusseau & Mancini, 2018).

The results of these studies are relevant for policymakers and stakeholders to comprehend the nature of the SDG interlinkages and to improve the SDG priority setting at the national level. Nevertheless, even if we still have low understanding of the SDG interactions, the existent literature in this topic have demonstrated that there are more positive interactions (synergies) than trade-off in the SDG network (Weitz et al., 2018; Nerini et al., 2017; Maes et al., 2019).

Even with its limitations, the analysis of interactions between SDGs are fundamentally important for politics and policymakers, considering that allows the identification of development priorities for the countries, the validation of strategic policies through the alignment with the prioritized SDGs (policy coherence) and the evaluation of strategies for development at the national level (Allen et al., 2018a), Le Blanc, 2015; Nerini et al., 2017; Karnib, 2017; Maes et al., 2019; Griggs et al., 2017).

The challenge of understanding the intricate and complex SDG network of interactions have been clearly explained by (Weitz et al., 2018), which have expressed: "*Understanding interactions between targets requires quite detailed information, but it also requires the ability to maintain a holistic view of the system as a whole, since it is possible that one policy change can change the dynamics of the whole system*".

2.2 Understanding the SDG Interlinkages

Considering the universality of SDGs, the diversity of sectors and stakeholders, the scarcity of resources, and the complexity of the interactions in the SDG network, is inevitable and almost obligatory, the identification of priorities within the SDGs (Allen et al, 2018; Weitz et al., 2018; McGowan et al., 2018; Alcamo, 2019; Nilsson et al., 2016; Scherer et al., 2018; Singh et al., 2018; Pereira et al., 2021). The selection of priorities within the SDGs, are the reflection of the strategies and policies that each country (expressed by its policymakers) has decided to adopt, considering the level of urgency in each sector (McGowan et al., 2018).

The study of the SDG interlinkages has rapidly evolved from the pioneer study of (Le Blanc, 2015), criticized for the superficiality of the analysis of the interactions between SDGs and the mapping visualization. Similarly, (Vladimorova & Le Blanc, 2016) have presented an analysis of official reports from the United Nations to evaluate the interactions between education and SDGs, using the wording reference methodology. Again, as in the previous study, the results lack of deepness in the analysis of the SDG interlinkages.

Applying the network approach and reinforcing the results presented by (Le Blanc, 2015) about the asymmetry of the interlinkages between the SDGs, (McGowan et al., 2018) highlight that those interlinkages are uneven, observing the lack of connections between critical SDGs as those related to gender equality, peace, and governance. These authors have based their analysis on the report from the (Griggs et al., 2017) and based on the interactions identified on it from a science-based perspective (ICSU, ISSC, 2015), they constructed a SDG network of interactions considering 4 main elements: degree (number of links per node), strength (total number of links from a node), closeness (distance with other nodes in the network and centrality of a node in the network), betweenness (flow of information through the network).

Following with the use of the network approach, (Allen et al., 2018) and (Allen et al., 2018a) have implemented a network analysis of SDG targets interlinkages for 22 Arab countries, based on the assessment scale of (Nilsson et al., 2016) for the evaluation of the intensity of the interactions (from -3 to +3), through a cross-impact matrix to identify

synergies, trade-off, and neutral interactions. The SDG network, obtained through an expert elicitation process, considers to 2 main network metrics: the outdegree and closeness centrality. These results are later used as inputs for the evaluation of policy gaps and the design of a multi-criteria analysis, helping to set the development priorities for the Arab region.

Using the same methodology, (Weitz et al., 2018) have evaluated the interactions between 34 SDG targets, obtaining results that reinforce the hypothesis that there are more synergies than trade-off in the SDG network, but in which the trade-off represents a serious threat for the accomplishment of the 2030 Agenda worldwide. The SDG network obtained in this study provides a deeper level of analysis, showing the directionality of the interactions between SDG targets, the type of interactions, the intensity of the influence of targets in the SDG network, and the clusters of SDG targets in the network.

Recently (Lusseau & Mancini, 2018) analyzed how the interactions of the SDGs, at the goal and target levels, vary according to the level of income of countries. The results show the existence of unstable networks, composed by antagonistic subgroups, where the identification of development of priorities in each country is needed.

2.3 SDG Priorization & Economic Complexity

The study from (El-Maghrabi et al., 2018) has set the foundations for the use of the principles of economic complexity and the product-space theory in the challenge of setting priorities within the SDGs, based on the capabilities of each country. This study, from the World Bank, has only made a methodology proposal and offered only a few examples of its utility, having a very limited scope.

In the same context, (Pereira et al., 2021) broaden the scope of the methodology proposed by (El-Maghrabi et al., 2018) and offered a wider perspective on how countries could use the economic complexity principles and the product space theory to set priorities, to rank the SDGs according to their complexity (Goal Complexity Index), and to rank the countries according to their performance towards sustainable development (Sustainability Complexity Index).

The results from (Pereira et al., 2021) show that according to the Goal Complexity Index (GCI), the top 3 of more complex goals in the 2030 Agenda, are the SDG12 (Responsible Production & Consumption), SDG13 (Climate Action) and SDG17 (Peace, Governance & Partnerships). In the other hand, the least complex goals are SDG9 (Industry, Innovation, and Infrastructure), SDG3 (Health & Wellbeing) and SDG7 (Energy). In this context, an optimal strategy for countries could be following the sustainability complexity path, to fully achieve the 2030 Agenda, advancing from the accomplishment of less complex goals to more complex goals,

From the perspective of the Sustainability Complexity Index (SCI), the results show that the biggest challenges for the accomplishment of the SDGs mainly remain in Africa and Southeast Asia. In South America, Bolivia and Venezuela present the lowest levels of SCI.

It is important to note that the work carried out by (Pereira et al., 2021) resulted in the inspiration for the realization of this work and resulted in the methodological proposal that is presented as an alternative for the study of sustainable development objectives in an innovative way.

2.4 Economic Fitness

The Economic Fitness theory proposes a new algorithm that shows an iterative and non-linear approach, which makes it possible to efficiently capture the link formed between the export basket of different countries and their industrial competitiveness (Tacchella et al., 2012; Cristelli et al., 2013; Tacchella et al., 2013). This model has its initial basis in the construction of a binary matrix of countries and products (*Mcp*), which represents the export basket of each country, whose elements are 1 if country *"c"* exports product *"p"* with revealed comparative advantage and 0 otherwise. This method consists of coupled nonlinear maps, and in each iteration new information is added.

Therefore, the general idea of the algorithm proposed in the Economic Fitness theory lies in defining an iteration process for the fitness of the countries (F_c) with the complexity of the products (Q_p), and then obtaining the values of the convergence. In the case of F_c, it is appropriate that it be proportional to the sum of the exported products weighted by their complexity Q_p.

For the case of Q_p it becomes less intuitive, because, in a first approximation, the complexity of a product is inversely proportional to the number of countries that export it. But in each iteration more information is added considering that, if a country has a high level of Fitness, the weight is reduced to limit the complexity of a product, on the other hand, countries with low Fitness contribute more and tended to limit the complexity of the products (Tacchella et al., 2012; Cristelli et al., 2013;

Tacchella et al., 2013; Pugliese, Zaccaria & Pietronero., 2016). These ideas are summarized in the iteration of the following equations:

$$\begin{cases} \tilde{F}_c^{(n)} = \sum_p M_{cp} Q_p^{(n-1)} \\ \tilde{Q}_p^{(n)} = \dfrac{1}{\sum_c M_{cp} \dfrac{1}{F_c^{(n-1)}}} \end{cases} \rightarrow \begin{cases} F_c^{(n)} = \dfrac{\tilde{F}_c^{(n)}}{\langle \tilde{F}_c^{(n)} \rangle_c} \\ Q_p^{(n)} = \dfrac{\tilde{Q}_p^{(n)}}{\langle \tilde{Q}_p^{(n)} \rangle_p} \end{cases}$$

Where:

$n =$ Index of iteration.
$c =$ Total number of countries.
$p =$ Total number of products.
$F_c =$ Fitness of the country "c".
$Q_p =$ Product Complexity "p".
$M_{cp} =$ Product − Country Logical Matrix.
$Obs.$: $\tilde{F}_c$ and $\tilde{Q}_p$ corresponding to the normalization

Since this theory proposes that less complex exporters make a dominant contribution to product complexity, nonlinearity is a fundamental mathematical property that is unavoidable in view of the problem of economic diversification (Cristelli et al., 2013). For the definition of the complexity of the products, the sum in the denominator is strongly dominated by the countries that have a lower Fitness measure. Another issue that must be considered when considering the product complexity denominator is that, as the total number of countries that export that specific product increases, this means that the complexity of the products decreases, considering thus the ubiquity of the product.

To establish the M_{cp} Matrix, which allows the calculations of the Economic Fitness, it is necessary to consider the Revealed Comparative Advantage. The definition of Revealed Comparative Advantage (RCA) proposed by Balassa (1965), is used to make countries and products comparable, since it represents the exports of products by country. This index establishes that a country has revealed a comparative advantage in a product if it exports more than the rest of the world, in which case the RCA index adopts a value equal to or greater than one; if it is less than one, it indicates the opposite. It is formally defined as:

$$RCA_{cp} = \frac{\dfrac{X_{cp}}{X_{cT}}}{\dfrac{X_{Mp}}{X_{MT}}}$$

Where:
$X_{cp} =$ Exports of the country "c" of the product "p".
$X_{cT} =$ Total Exports of the country "c".
$X_{Mp} =$ Total World Exports of the product "p".
$X_{MT} =$ Total World Exports of the year (All Products).

This measure makes it possible to build a matrix that connects each country with the products it manufactures. The entries in the matrix are 1 if the export of the product in each country with Revealed Comparative Advantage is greater than or equal to 1, and 0 otherwise. We formally define this as the M_{cp} (Haussman et al., 2014) matrix, as:

$$M_{cp} = \begin{cases} 1, & \text{if } RCA_{cp} \geq 1 \\ 0, & \text{otherwise} \end{cases}$$

3 METHODOLOGY

3.1 Methodological Design: Sustainability and Goal Fitness Index

This research proposes a methodology that takes advantage of the concepts of Economic Fitness for the creation of a **Sustainability Fitness Index (SFI)** of the countries and a **Goal Fitness Index (GFI)** for each SDGs. These indices are intended to provide a tool to analyze the interrelationships between the Sustainable Development Goals in such a way as to offer a new approach for addressing the capabilities of the countries and the fulfilment of the SDGs.

To achieve the implementation of the proposed methodology, two fundamental steps are required. The first step is to identify the SDG compliance capabilities of each of the study countries, like the use of the RCA index proposed by Balassa (1966); and in a second step, perform the calculations of the SFI and the GFI based on the mathematical models proposed by Tacchela et al., (2012).

Step 1: Goal Achievement Capability (GAC)

Each country is responsible for voluntarily reporting its progress in terms of compliance with the different SDGs. Each of the 17 Sustainable Development Goals requires specific capabilities to be achieved. Although each country is different and has its own challenges to achieve the goals, however, the capabilities required for their achievement will possibly be very similar (at least to a great extent). Then, considering the concepts of comparative advantages, an index based on the **Goal Achievement Capability (GAC)** is proposed, which will indicate the relationship between the SDGs (achieved) and the countries, establishing a country/goal matrix (M_{cg}) like the proposal in Pereira et al., (2021).

To determine the value of the Goal Achievement Capability, we propose the use of data obtained from

the public database from the Sustainable Development Report 2019 proposed by Sachs et al., (2019). In this database, a qualitative evaluation is presented, based on the performances reported by the countries in each SDG, where we can observe a 4-colour scale: Green = Goal Achievement; Yellow = Challenges Remain; Orange = Significant Challenges and Red = Major Challenges.

Given the scale, we propose that for any SDG that presents a performance colour other than "Red", it will be considered that the country has the minimal capabilities to meet the SDG. So, it is represented by the following equation:

$$GAC_{cg} = \begin{cases} 1 & if\ Goal \neq Red \\ 0 & otherwise \end{cases}$$

Once the GAC value is obtained for each country and for each goal, a logical matrix of countries by goals is created, which we call M_{cg}, where, for this model based on the available data on compliance with the SDGs, it is necessary to $M_{cg} = GAC_{cg}$

Step 2: Calculation of the Sustainability Fitness Index and the Goal Fitness Index

Once the capabilities to meet the goals of each SDG for each country have been identified, the mathematical models used in the Theory of Economic Fitness [Tacchella et al., 2012] (See Section 2.4) for the analysis of the SDGs are extrapolated. The following equations are used:

$$\begin{cases} \widetilde{\mathrm{SFI}}_{\mathrm{c}}^{(\mathrm{n})} = \sum_{g} \mathrm{M}_{\mathrm{cg}} \mathrm{GFI}_{g}^{(\mathrm{n}-1)} \\ \widetilde{\mathrm{GFI}}_{g}^{(\mathrm{n})} = \dfrac{1}{\sum_{\mathrm{c}} \mathrm{M}_{\mathrm{cg}} \dfrac{1}{\mathrm{SFI}_{\mathrm{c}}^{(\mathrm{n}-1)}}} \end{cases} \rightarrow \begin{cases} \mathrm{SFI}_{\mathrm{c}}^{(\mathrm{n})} = \dfrac{\widetilde{\mathrm{SFI}}_{\mathrm{c}}^{(\mathrm{n})}}{\langle \widetilde{\mathrm{SFI}}_{\mathrm{c}}^{(\mathrm{n})} \rangle_{\mathrm{c}}} \\ \mathrm{GFI}_{g}^{(\mathrm{n})} = \dfrac{\widetilde{\mathrm{GFI}}_{g}^{(\mathrm{n})}}{\langle \widetilde{\mathrm{GFI}}_{g}^{(\mathrm{n})} \rangle_{g}} \end{cases}$$

Where:

$\mathrm{n} = \mathrm{Index\ of\ iteration.}$

$\mathrm{c} = \mathrm{Total\ number\ of\ countries.}$

$\mathrm{g} = \mathrm{Total\ number\ of\ goals.}$

$\mathrm{SFI_c} = \mathrm{Sustainability\ Fitness\ of\ the\ Country\ "c".}$

$\mathrm{GFI_g} = \mathrm{Goal\ Complexity\ of\ the\ Goal\ "g".}$

$\mathrm{M_{cg}} = \mathrm{Country - Goal\ Logical\ Matrix.}$

Obs.: $\widetilde{\mathrm{SFI}}_{\mathrm{c}}$ and $\widetilde{\mathrm{GFI}}_{\mathrm{g}}$ corresponding to the normalization

3.2 Methodological Steps

A work based on structured methodology in 5 well-defined steps was carried out.

Step 1: Identification of Secondary Databases

All data used for this study were obtained from the following secondary sources:

- SDG compliance data they were obtained from the public database from the Sustainable Development Report 2019 proposed by Sachs et al., (2019)
- Socio-Economic Data: Datos.bancomundial.org, URL: https://datos.bancomundial.org/indicator/NY.GDP.PCAP.CD

It should be noted that the data used for the study is available to interested parties[4].

Step 2: Design of the Complexity Fitness Mathematical-Computational Model for the Analysis of the SDGs

The mathematical-computational model was created based on the Economic Fitness models proposed by Tacchela et al., (2012) and runs were made using proprietary models in the software MatLab®. In case any interested party requires the models, they can request it from the authors without any inconvenience.

The scope of the study covered a total of 191 countries. The countries Haiti and Somalia were not considered for this study because they have not registered any SDG for which they have a GAC (GAC_{cg} = 1), which does not allow an adequate analysis for the proposed model.

On the other hand, the convergence of the model when considering the SFI occurs on average at iteration 24, and when considering the GFI it occurs on average at iteration number 25, in both indices a $tolerance = 10^{-6}$ how to stop point for iterations.

Step 3: Validation of the Results of the Sustainability Fitness Index

Validations were performed from two positions. The first corresponds to a comparison between the results obtained under this proposed model vs the results obtained by Pereira et al., (2021). On the other hand, some correlations were made with other known socio-economic indices to identify some correlation and thus analyze its implications.

Step 4: Results Analysis

Descriptive comments were made on the results obtained from the model, in addition to the results of the validations carried out.

[4] Data used for the study: https://bit.ly/34YTk0B

Step 5: Conclusions and Recommendations

After the analysis of the results, a conclusion on the methodological proposal is presented, as well as a critical review of the results and the model presented.

4 RESULTS

Results related to SFI and GFI were obtained, in addition to the validations carried out for the model.

In terms of the SFI, results were obtained for 191 countries, where their sustainability capabilities can be inferred based on compliance with the SDGs. Figure 1 shows graphically the general results of the SFI.

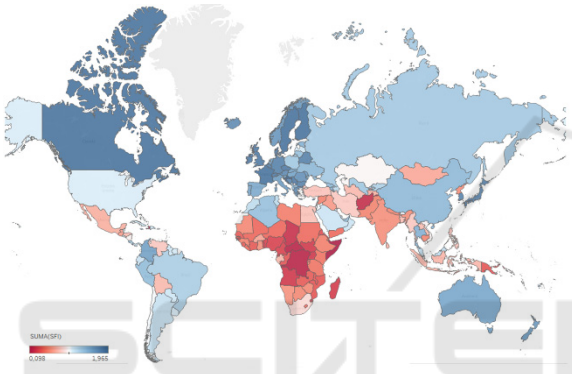

Figure 1: Worldwide SFI 2019.

The Figure 1 show the results SFI through heat map for the year 2019, where warmer colors reflect lower levels of sustainability fitness. Then, from Figure 1, the biggest challenges for the accomplishment of the SDGs mainly remain in Africa and Southeast Asia. In the same context, the biggest challenge in South America seems to be in Bolivia, Chile, Venezuela, and Ecuador. Nevertheless, from the results of the SFI we can observe a diversity and heterogeneity of performances worldwide, with countries showing a strong path towards sustainable development and the achievement of the SDGs.

For example, in Table 1 we can observe the list of the top-10 performers in the SFI, finding mostly European and high-income countries. In the other hand, in the list of worst performers in the SFI (Table 2), we mainly find African and low-income countries. However, further studies are needed to improve our understanding of the correlation and causality between performance on the SFI, level of income and the achievement of the SDGs worldwide.

Table 1: Top-10 best performers SFI 2019.

Rank	***Country***	***Id.***	***SFI***
1	*Croatia*	HRV	1,965
2	*Canada*	CAN	1,867
3	*Finland*	FIN	1,867
4	*France*	FRA	1,867
5	*Sweden*	SWE	1,867
6	*Switzerland*	CHE	1,827
7	*Denmark*	DNK	1,827
8	*Czech Republic*	CZE	1,824
9	*Serbia*	SRB	1,824
10	*United Kingdom*	GBR	1,813

Table 2: Top-10 worst performers SFI 2019.

Rank	***Country***	***Id.***	***SFI***
184	*South Sudan*	*SSD*	0,254
185	*Angola*	*AGO*	0,251
186	*Uganda*	*UGA*	0,242
187	*Micronesia, Fed. Sts.*	*FSM*	0,230
188	*Chad*	*TCD*	0,203
189	*Afghanistan*	*AFG*	0,190
190	*Haiti*	*HTI*	0,152
191	*Central African Republic*	*CAF*	0,149
192	*Congo, Dem. Rep.*	*COD*	0,149
193	*Somalia*	*SOM*	0,098

Table 3: Ranking of GFI 2019.

Rank	***Goal***	***GFI 2019***
1	*Goal 16*	*2,073*
2	*Goal 2*	*1,962*
3	*Goal 3*	*1,689*
4	*Goal 9*	*1,434*
5	*Goal 10*	*1,295*
6	*Goal 6*	*1,136*
7	*Goal 1*	*0,984*
8	*Goal 5*	*0,851*
9	*Goal 8*	*0,806*
10	*Goal 7*	*0,802*
11	*Goal 14*	*0,779*
12	*Goal 4*	*0,760*
13	*Goal 11*	*0,674*
14	*Goal 17*	*0,466*
15	*Goal 15*	*0,443*
16	*Goal 13*	*0,435*
17	*Goal 12*	*0,411*

In Table 3 you can see the result obtained for the GFI. The SDGs that are at the bottom of the ranking are those for which the least capabilities are required for their implementation in the countries. On the other hand, the SDGs with the highest GFI and therefore located in the first places, correspond to those that are

highly complex, so not many countries have the capacity to achieve them.

On the other hand, following the results obtained in the validation process of the SFI 2019, four correlation analyzes were carried out with: The GDP_{pc}; The Rank of Global Competitiveness Index; The Rank of Government Effectiveness; The Rank of Human Development Index for all countries covered in the study for the year 2019.

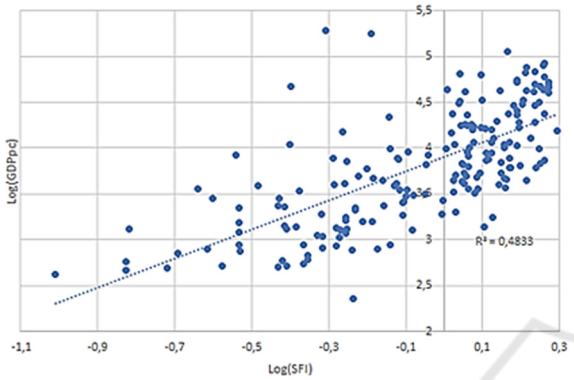

Figure 2: Relation between SFI 2019 Vs GDP_{pc} 2019.

There is a very interesting trend in terms of the SFI and the level of the GPD_{pc} of the countries. It could be inferred that as the GPD_{pc} increases, the SFI also increases. Therefore, it is an element that could be important to increase the fitness of countries in terms of sustainability (See Figure 2).

This behavior is also repeated when the SFI is subjected to correlation with other indices such as the Rank of Global Competitiveness Index and the Rank of Government Effectiveness. Both high indices imply that the countries are highly competitive and effective. It is not strange to infer that they have the capacity to implement programs and public policies, which would at least make it easier to establish and comply with plans and actions that allow achieving sustainability goals. In Figure 3 and Figure 4 the mentioned behavior can be clearly observed.

Regarding the behavior of the connection between the SFI and the HDI, an interesting connection could also be observed. This allows us to infer a priori that countries with a HIGH index may have greater capacities to achieve sustainability goals. It would be necessary to carry out more studies and with a greater range of years to obtain better observations and therefore better conclusions on this point (See Figure 5).

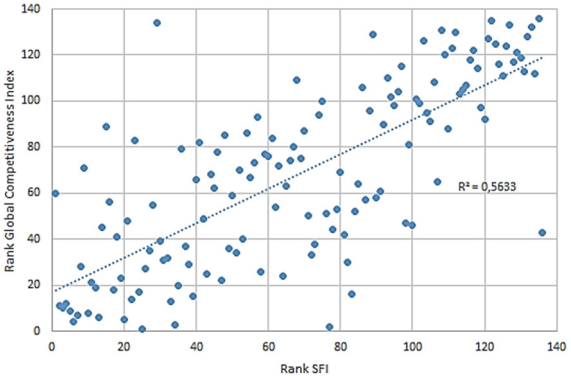

Figure 3: Relation between Rank of SFI 2019 Vs Rank of Global Competitiveness Index 2019.

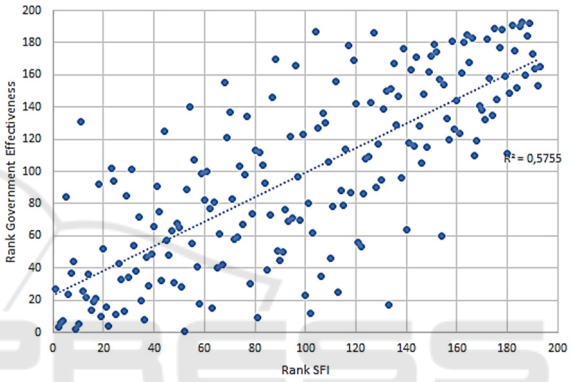

Figure 4: Relation between Rank of SFI 2019 Vs Rank of Government Effectiveness 2019.

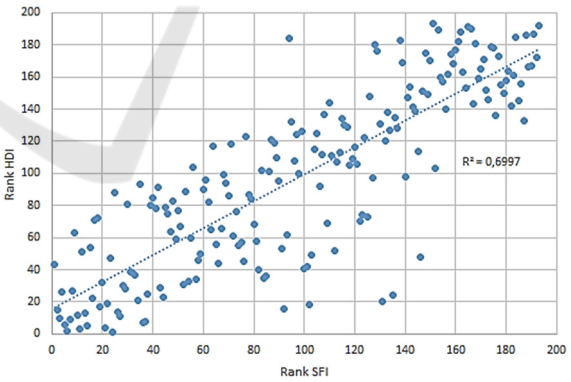

Figure 5: Relation between Rank of SFI 2019 Vs Rank of Human Development Index 2019.

5 CONCLUSIONS

The methodological approach proposed in this study aims to guide the policy-design and decision-making in countries, through the use and consideration of data, capabilities, comparative advantages, and

fitness metrics. As in previous studies, the analysis of the SFI is limited to the availability of data series, public information, and reliable data on the progress of the countries in their performances in the different SDGs. It must be underlined, that the methodology used for the SFI is limited, because the data from the SDG Report are not comparable year-by-year. However, the Sachs et al., (2021) has stablished a definitive methodology that will allow data comparability for the following years.

The results of the SFI are a first attempt to identify development priorities aligned with the SDGs in each country, based on their available productive capabilities, which could help to make a more efficient use of their limited resources and boost the achievement of the SDGs. Following this path could help the country countries to accelerate their way towards sustainable development and to create synergies within the SDG network.

It is important to highlight that by taking the Economic Fitness model, applied to the analysis of the SDGs, it is possible to take advantage of the virtues to obtain more information about the capabilities necessary to achieve a goal. This occurs because the countries that achieve few goals provide more information, since it can be inferred that the goals that these countries have achieve with less capabilities than others and have still managed to meet them.

For the next steps, we suggest further studies on the SFI and GFI, to improve the experimentation and validation of the mathematical model and fitting the parameters used to define which countries presents the minimal capabilities to achieve an SDG.

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AUTHORS CONTRIBUTIONS

Activities	Methodology	Literature Review	Mathematic Model	Data	Manuscript	Calculations	Results Analysis
S.G.	X		X		X	X	X
G.P.		X		X	X		X
A.G.	X		X		X		X

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