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Semantic network analysis of sustainable development goals to quantitatively measure their interactions

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ABSTRACT

Following the Sustainable Development Goals proposed by the United Nations in 2015, several countries, institutions, and people have been involved in the design of policies and implementation of practices relating to environmental, social, and human development. The structure of internal relationships that underlie official documents that detail the seventeen sustainable development goals can have a considerable influence on the prioritization of these policies. This study analyses the semantic network that exist between the goals proposed by the United Nations, comparing their English and Spanish versions. The results show some similarities between methods and languages in the most and least connected goals. The least connected goals appear to need greater attention as they are more independent and their targets are not connected to the other goals' targets. The semantic network that has been analysed enables the visualization of the strength of the connections between goals within the official texts and can be a tool for ensuring a better understanding of these goals and creating policies that linked several of them with one another.

1. Introduction

The Sustainable Development Goals (SDGs) cover all aspects of sustainable development within their three axes: social, economic, and environmental (United Nations, 2015b). Each of the goals written by the United Nations has a title, a description, and a detailed list of targets and indicators that cover the specific purpose of the goal. The targets are detailed texts that act as a guide and reference for the countries and institutions that use these goals to design their policies and actions. The SDGs cover many interrelated disciplines, such as the environment, agriculture, education, justice, and sociology. To implement governance based on these SDGs, these relationships should be considered. For many years researchers have recognized that economic systems can affect the environment or social problems (Altvater, 1995). As a result, in its 2019 report, the UN explained that to fight climate change, there must be a shift towards renewable energy sources, and this can affect ecosystems as well as production and consumption systems. Similarly, access to drinking water can improve health and education, as it enables children (who are the individuals who usually search for water) to have

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more time to go to school (United Nations, 2019). Other authors have demonstrated that if there is no connection between energy, water, and food, this can have significant consequences on applications of developmental policies (Rasul, 2016). These examples are just a few of many.

There are several existing studies on the interactions between SDGs. One of them (Nilsson et al., 2016) analysed the interactions between all of the SDGs and determined the extent to which some interactions strengthen or weaken others. A seven-point scale was used to score the different interactions. The scale was based on experts' judgement and has been justified in other related studies. The results of this study showed that all the SDGs interacted and that understanding these relationships, both positive and negative, was the key for their implementation. In general, the most common score was +2 (reinforcement), which meant that most of the goals had positive reinforcement connections and were unlikely to be negative. In other study Sachs et al. (2019) suggested converting the SDGs into six overall categories, in which the goals for each group are in some way linked with one another. The first category would include Education, Gender and Equality; the second, Health, Wellbeing and Demographics; the third, Energy & Sustainable Industry; the fourth, Food, Water, Sustainable Lands & Oceans; the fifth, Sustainable Cities & Communities; and the sixth, Digital Revolution for Sustainable Development. Kanie et al. (2014) studied the SDGs groups by selecting keywords from two categories: human wellbeing and planetary wellbeing, which considered the axes of the development agenda. From another perspective, Lusseau and Mancini (2019) analysed the SDGs' interaction networks using a time series for the SDG indicators amongst countries with different levels of income. All of these studies analyse the SDGs' relationships using qualitative analysis based on expert opinion, although they do not carry out a complete interaction network analysis, which could be useful for understanding how these connections are structured and for using the network during the planning task.

The information provided above shows that the SDGs form part of a complex system and that there are many provable interactions between them. However, there are few studies that quantify these interactions from a global perspective. An analysis performed by Le Blanc (2015) at the United Nations Department of Economic and Social Affairs used network analysis to connect the different SDGs and establish relationships between the targets of each of the goals and the goals themselves. Le Blanc carried out an analysis of networks between goals, whilst also using a methodology based on his expert opinion. However, an expert's subjective judgement tends to be prone to various biases as it is limited to an individual's knowledge and experience (Varela-Ruiz et al., 2012). Therefore, it would be interesting to extend these studies with a methodology that is not based on the researcher's judgement, that can be replicated, and whose results can be easily quantified. In addition, the SDGs have an interdisciplinary and interrelated nature that can generate conflicts of interest, especially when it comes to economic matters, and social or environmental problems must also be considered (Nogueira, 2019).

The SDG targets are set out in the official documents that are a product of the consensus amongst development experts from around the world, and this should therefore ensure that the textual information is coherent, and that the relationships between goals are implicit in the text. Semantic Network Analysis (SNA) can be used to analyse the interactions that are reflected in the official documents. SNA enables the measurement of the interactions that were analysed between the different documents and it can help to visualise these interrelations. In addition to its ability to quantify the interactions in an objective manner, it can help to understand the intensity of the connections between each of the goals.

1.1. Semantic network analysis

SNA is a tool used in Text Mining and is based on a combination of two sciences, computational linguistics, and text processing. Initially, mining techniques were developed to recover information, although they are currently used for digital documentation, search engines, databases, and scientometrics (Boeris, 2013). Eito Brun and Senso (2004) described the primary uses for text mining as follows: *"identify specific facts and information based on the document's text; determine the subject(s) covered in the documents; identify the concepts covered in the documents and create concept networks …"* . This tool has been used since the 1980s, sometimes under less commonly used names such as Concept Diagrams, Concept graphs or Concept Networks. In addition, when semantic analysis has been used to count words, it has also been referred to as text analysis or textual analysis (Carley, 1993). However, the terminology of Semantic Network Analysis arose once Danowski & Barnett started to use it more frequently (G. Barnett, Danowski and Richards, 1993; Danowski, 1993; Rasul, 2016).

In an exhaustive review of these techniques, Doerfel (1998), considered that semantic networks have two main uses: the study of the cognitive framework of the person who creates the discourse, and the study and representation of conceptual frameworks for other uses. The work by Danowski (1993) was focused on cognitive study. He designed an automatic coding methodology that detected the co-occurrence of concepts. Co-occurrence refers to the appearance of the same words or concepts in a text or group of texts and measuring the distance between the position of some words compared to others. Schnegg and Bernard (1996), on the other hand, focused on semantic associations or groups of concepts used to understand the terms that are most commonly used by a specific group of people. Another similar study by Jang and Bamett (1995) investigated the culture of an organization, identifying groups of common words.

Semantic networks are being used increasingly in research across multiple disciplines, including: political discourse analysis (G. A. Barnett et al., 2017; Xiong et al., 2019), the presence of a concept (Gloria J Kang et al., 2017; Jiang et al., 2018; Salloum, Al-emran, & Shaalan, 2017) or brand on social media networks (Saez, 2019), analyses of news topics in specific countries (Jiang et al., 2017), etc. Psychologists such as Collins or Loftus (1975) worked with cognitive psychology and human semantic memory. In the same era, Collins and Quillian (1969) worked together to develop artificial intelligence using semantic memory and natural-language understanding. In short, this is a methodology that has wide scientific backing and that can be used to analyse interdisciplinary documents, as is the case with the SDGs.

The objective of this study is to use Semantic Network Analysis to study the structure of the relationships between the 17 SDGs, something which has been reflected in an implicit manner in the wording of the official documents that were agreed at a global level: The United Nations' A/RES/70/1 Resolution Document *Transforming our world: The 2030 Agenda for Sustainable Development* (United Nations, 2015a, 2015b). This document has been written in several languages, in which the relationship that emerges could be different based on grammatical structure and the semantic fields used in each of the UN's official languages. A comparison between the document in English and Spanish was carried out, with the purpose of understanding whether there are significant differences in their comprehension.

2. Methodology

The semantic network used in this study are based on the co-occurrence of keywords between different texts that describe the SDGs' targets. The frequency with which they appear in each of the texts has been measured. The software used for this analysis are: Linguakit (Cilenis Language Technology S.L, 2017) for the semantic analysis of texts, which helps to automatically classify words based on their grammatical category, and Ucinet (Borgatti et al., 2002) for network analysis, which represents the network between goals and calculates the value of these interactions. Ucinet is mainly used in analyses of social networks, although analyses of semantic networks are executed in almost the same manner, replacing the nodes of people or organizations for words or concepts.

Obviously, in a global document translated into several languages there should not be substantial differences in a semantic network analysis based on the language. However, in order to prove this, this analysis compares results in the two languages English and Spanish, that are most widely spoken and used in the global expert community: (Europa Press, 2019). The most ideal network of words for analysing relations would be one that is similar in both languages, as the UN's intention is that the SDGs should be understood in the same way in all countries.

In order to analyse the documents, firstly the study's entity must be defined. This is usually words, which are considered the basic level of semantic value; terms, which can be individual words or groups of words that are commonly used together; and concepts, which are ideas and expressions extracted by using multiple complex methodologies (Feldman and Sanger, 2007). In this case, the entity that is chosen to automate the analysis is the word. Once the entity has been selected, there are two stages: pre-processing and core mining operations.

2.1. Pre-processing

Pre-processing serves to extract the entities and reduce the combinations as much as possible until they are manageable, eliminating everything that is not useful for the analysis. Within this stage, natural language processing (NLP) also takes place, as well as the categorization or grouping of texts and information extraction. To discover the relationships between the SDGs in the texts, the keywords or concepts must first be extracted. To select the keywords for our study, the first step was to eliminate stop words (Luhn, 1960), starting with those in the grammatical category (prepositions, determiners, pronouns, conjunctions) as they lack meaning. Subsequently, other possible stop words were designated for detection based on the study's objective. The keywords that have been analysed are not the keywords from the SDGs, but rather those that help to connect them, i.e., words that appear in more than one SDG. The keywords for each goal that do not appear in other goals have been eliminated. Those words that appear several times but in only one of the SDGs have also been eliminated, as they are not useful for establishing a connection. Subsequently, four methods for selecting keywords have been used to reduce the number of words by rejecting those that are considered stop words, as shown in Table 1. The first method uses the factor Tf-Idf (Johnson, 2019; Spärck Jones, 1972) that identifies keywords based on their frequency in a text. The other three methods automatically (M2 and M3) or manually (M4) select keywords and exclude words that are considered stop words (adverbs, verbs, and generic words, depending on the method).

- M1. Automatic selection of keywords using Tf-Idf: This begins with words from a lexical category (nouns, adjectives, adverbs, and verbs) that appear in various SDGs. The Tf-Idf factor is calculated for each word in each target to understand what the keywords are for each goal based on their frequency, thereby eliminating words with a Tf-Idf factor of zero. The Tf-Idf value increases proportionally to the number of times a word appears in the document, but is offset by the frequency of the word in a collection of documents, which accounts for some words being more common than others.
- M2. Automatic selection of keywords as nouns, adjectives, and verbs, excluding adverbs.
- M3. Automatic selection of keywords as nouns and adjectives, excluding adverbs and verbs.

Table 1
Number of words in each selection method and language.

	English	Spanish
Lexical category words in more than one SDG	445	489
M1. Words for calculating Tf-Idf	445	489
M2. Nouns, Adjectives and Verbs in more than one SDG	424	479
M3. Nouns and Adjectives in more than one SDG	353	393
M4. Nouns and adjectives without generic words	250	152

- M4. Handpicked keywords as nouns and adjectives, excluding adverbs, verbs, and generic words. Previously, three types of words have been identified in the texts: specific, semi-specific, and generic. Specific words appear in only one goal and have already been discarded in the first stage. Generic words can appear in various goals, but do not provide the SDGs with semantic content. Semi-specific words appear in various goals and can help to connect them. These are of most interest to us; therefore, the generic words should be discarded. It is not possible to discard such words with the use of a software or other non-manual methods, as has been the case in methods 1, 2 and 3. Furthermore, generic words can have the same frequency as semi-specific examples, and it is therefore necessary to eliminate the former manually based on the list of words obtained in method 3. This final step helps to reduce the bias caused by generic words. The elimination was ultimately carried out based on the criteria from four experts.

2.2. Core mining operations: semantic network analysis

Techniques used depend on the study's aims (Antons et al., 2020; Feldman and Sanger, 2007). One analysis option is to establish links between entities using coincident information or semantic relations between the entities. This technique is called Semantic Network Analysis, and once a list of keywords has been extracted and their frequency is understood, the relationships between documents can be established using calculations and representations based on graph theory and network analysis.

Having selected the keywords, each SDG has been defined by a group of keywords for each method (Table 1) and language. A matrix has thus been created for each language and method, in which the rows contain words and the columns contain goals. Two network analyses have been carried out; the first enabled us to determine the goals that were generally the most connected with keywords, whereas the second enabled us to discover the goals that were most connected with each other.

The matrices of words and goals input into to the Ucinet network software (Borgatti et al., 2002), which then created undirected and valued graphs to represent the matrices. A graph is undirected when the relationships do not have a direction from one node to another, meaning that some goals are related to others, without knowing which is the direction of the influence. A graph is valued when the lines of the network measure the strength or intensity of the relationship. The network analysis software can calculate, amongst other parameters, the network's centrality measures of degree, closeness, and intermediation. The degree centrality is the number of other nodes that one node is directly linked to. Intermediation centrality is the number of times a node appears between the paths that connect the pairs of other nodes, thus serving as a bridging node. Closeness centrality is the ability for a node to reach all the other nodes in a network and is calculated using the geodesic distance from the node to all the other nodes. The indirect relationships between nodes can also be traced, such as the paths that go from one node to another, while also passing through other nodes (Wasserman and Faust, 1994).

3. Results

The results shown in Table 2 are the centrality degree goals for each of the four methods. These demonstrate that the use of a certain method leads to slightly different results. In terms of the relationships between goals, Fig. 1 shows the value of the goals based on their centrality in relation to keywords. The SDGs with the greatest centrality are different in each language, although the methods provide similar results for the most extreme goals, i.e., those that are most and least connected.

As shown in Fig. 1, method 1 is evidently similar to methods 2 and 3. Method 4 maintains practically the same goals in the most and least connected positions, the curve is less noticeable, and there is less distance between the centrality values. The intermediate goals

Table 2
SDGs Centrality Degree for each method and language.

	Spanish				English			
	M1	M2	M3	M4	M1	M2	M3	M4
SDG 1	88	89	72	37	81	79	64	39
SDG 2	120	122	100	48	108	117	94	68
SDG 3	93	103	84	33	85	94	80	54
SDG 4	95	101	83	42	77	87	71	51
SDG 5	74	81	69	36	81	84	68	47
SDG 6	84	88	69	38	72	75	53	37
SDG 7	42	46	35	18	33	38	29	21
SDG 8	121	123	92	46	101	101	79	55
SDG 9	84	85	71	39	81	89	74	51
SDG 10	89	91	71	35	71	82	62	37
SDG 11	108	114	91	54	97	102	86	66
SDG 12	110	111	90	46	100	97	72	50
SDG 13	65	71	59	22	55	59	41	27
SDG 14	107	117	87	34	95	104	77	47
SDG 15	93	101	74	30	100	104	73	46
SDG 16	63	63	50	28	55	56	43	29
SDG 17	141	160	126	50	94	105	79	49
Mean	92,76	98,00	77,82	37,41	81,53	86,65	67,35	45,53
Dev.	24,21	26,48	20,53	9728	19,90	20,56	17,14	12,72

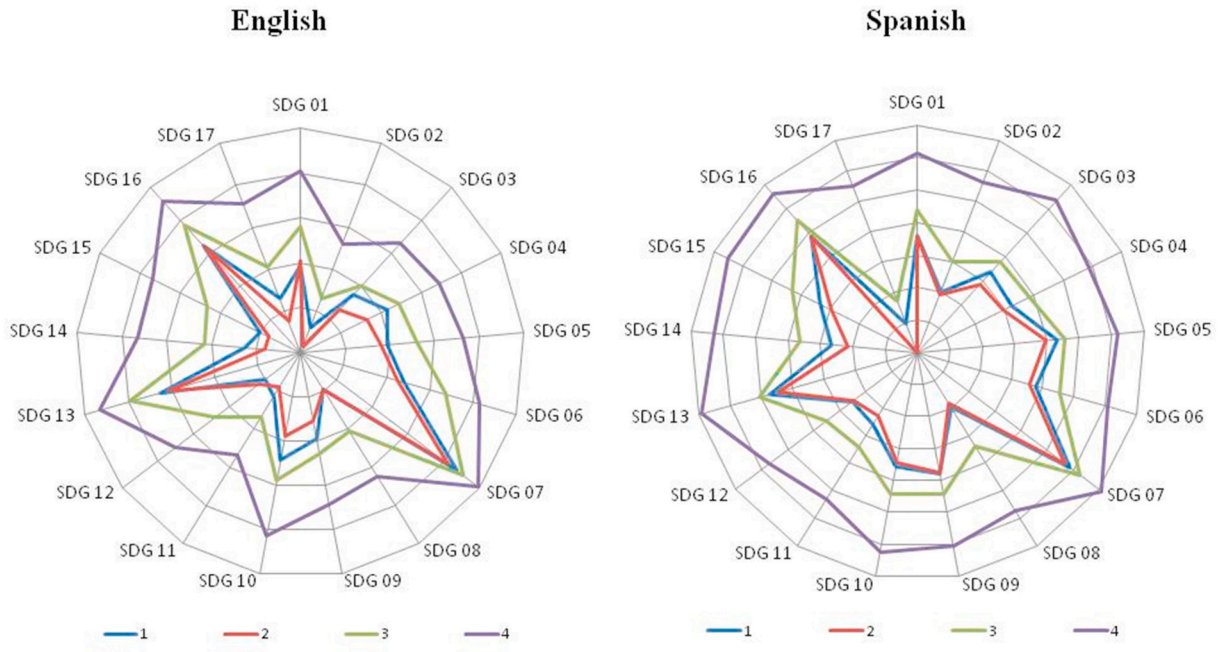

Fig. 1. SDGs values according to the centrality degree for each language and method. Note: The most connected SDGs are towards the centre and the least connected are away from the centre.

vary from one method to another and by language. In English, SDG 2 on hunger and sustainable farming is the most connected, whereas in Spanish, the most connected goal is SDG 17 on international partnerships. In contrast, the least connected goals are the same across all the methods.

Although there are some differences between the most connected goals between languages and methods, there is a clear pattern between the first and last positions, as shown in Table 3. This pattern includes central goals, which are the most connected, and outliers, which have fewer connections.

SDG 17 appears at the top in the first three methods in Spanish. This could be because it is the goal with the longest text and the

Table 3
Ranking of SDG centrality degree in each method and language.

	Spanish				English			
Ranking	**M1**	**M2**	**M3**	**M4**	**M1**	**M2**	**M3**	**M4**
1º	SDG 17	SDG 17	SDG 17	SDG 11	SDG 2	SDG 2	SDG 2	SDG 2
2º	SDG 8	SDG 8	SDG 2	SDG 17	SDG 8	SDG 17	SDG 11	SDG 11
3º	SDG 2	SDG 2	SDG 8	SDG 2	SDG 12	SDG 14	SDG 3	SDG 8
4º	SDG 12	SDG 14	SDG 11	SDG 8	SDG 15	SDG 15	SDG 8	SDG 3
5º	SDG 11	SDG 11	SDG 12	SDG 12	SDG 11	SDG 11	SDG 17	SDG 4
6º	SDG 14	SDG 12	SDG 14	SDG 4	SDG 14	SDG 8	SDG 14	SDG 9
7º	SDG 4	SDG 3	SDG 3	SDG 9	SDG 17	SDG 12	SDG 9	SDG 12
8º	SDG 3	SDG 4	SDG 4	SDG 6	SDG 3	SDG 3	SDG 15	SDG 17
9º	SDG 15	SDG 15	SDG 15	SDG 1	SDG 1	SDG 9	SDG 12	SDG 5
10º	SDG 10	SDG 10	SDG 1	SDG 5	SDG 5	SDG 4	SDG 4	SDG 14
11º	SDG 1	SDG 1	SDG 9	SDG 10	SDG 9	SDG 5	SDG 5	SDG 15
12º	SDG 6	SDG 6	SDG 10	SDG 14	SDG 4	SDG 10	SDG 1	SDG 1
13º	SDG 9	SDG 9	SDG 5	SDG 3	SDG 6	SDG 1	SDG 10	SDG 6
14º	SDG 5	SDG 5	SDG 6	SDG 15	SDG 10	SDG 6	SDG 6	SDG 10
15º	SDG 13	SDG 13	SDG 13	SDG 16	SDG 16	SDG 13	SDG 16	SDG 16
16º	SDG 16	SDG 16	SDG 16	SDG 13	SDG 13	SDG 16	SDG 13	SDG 13
17º	SDG 7	SDG 7	SDG 7	SDG 7	SDG 7	SDG 7	SDG 7	SDG 7

Note: The black lines separate the three groups of goals: the most connected, least connected and those in an intermediate position. The goals' colours correspond to the colours that the UN has used to identify them.

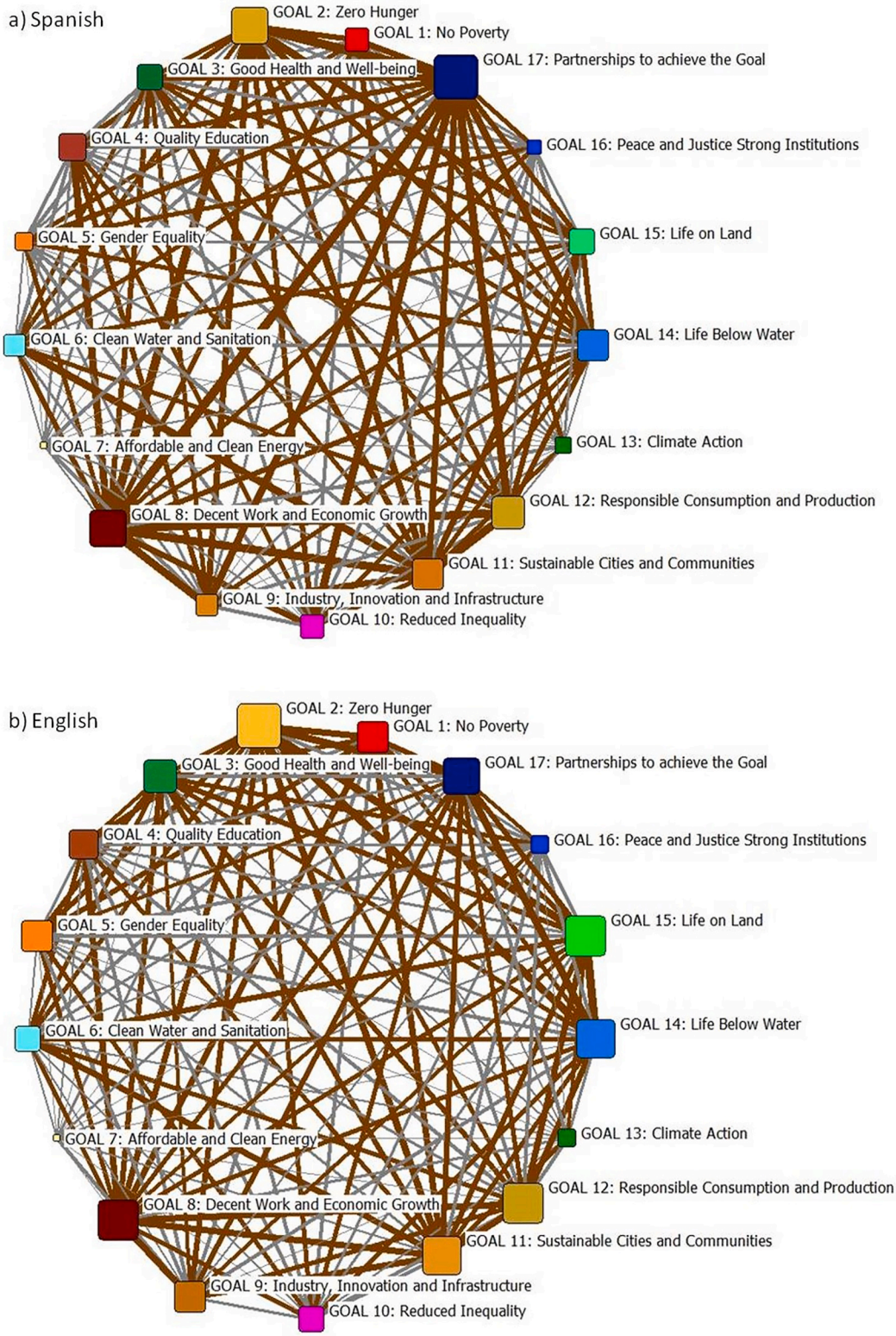

Fig. 2. SDGs network using Method 1. Note: Grey lines are connections with a number of common keywords below the 50th percentile and brown lines are connections with a number of common keywords above the 50th percentile. The node colours correspond to the ones officially used by the UN. The size of the node is based on the centrality degree. . (For interpretation of the references to colour in this figure legend, the reader is referred to the Web version of this article.)

most amount of words in both languages. However, it should also be the most connected goal in English. What can explain this difference between the Spanish and English texts? The reason is that in Spanish, SDG 17 contains more generic words (that do not add meaning to the SDG) and/or semi-specific words (that connect goals and interest us the most). In contrast, in English, the goal that has the most generic and semi-specific words is SDG 2. However, when method 4 is used and generic words are removed, SDG 17 drops its position, whereas SDG 2 remains the same. Therefore, we can confirm that SDG 17 appeared in the first position because of the generic words it contained. In the case of SDG 2, eliminating generic words did not affect its position; thus, it contained more semi-specific words than generic.

In terms of the least connected goals (7, 13, and 16), their positions are practically the same in all of the methods. The explanation could be because their texts are shorter, although the results indicate that this is not the reason. By eliminating specific words that only appear in that goal, these goals still have fewer generic and/or semi-specific words. When generic words are eliminated using method 4, these goals still maintain their position; thus, they also do not contain many semi-specific words compared to the others. Semi-specific words are those that connect goals and are exceedingly scarce within these examples.

As a result, method 4 eliminates generic words, thus providing more homogenous networks in both languages. However, this method incorporates a bias stemming from manual selection of the deleted words. Therefore, it was advisable to use one of the three automated methods that had similar results. We considered method 1 as the most reliable because it is an automatic method tested by experts in information recovery, and its values were similar to methods 2 and 3.

Our second analysis is carried out using a goal matrix in relation to other goals, in order to understand the interactions. The outputs of this are the networks in Fig. 2, which demonstrate how the relationships between objectives in different languages and methods change. Fig. 2 shows the network of relationships between goals in both languages for method 1. The specific links between each goal and the others are shown. The strongest connections are similar in English and Spanish, with slight changes.

As shown, the network is very dense because each goal is connected to the other 16 goals. What does vary is the intensity of these connections. In summary, the results show that the language influences the goal's centrality degree, as seen in Table 3, as well as the goal's interactions, as observed in Fig. 2.

4. Discussion

Now that the results have been obtained, three main discussion areas are proposed. Firstly, what does this methodology for analysing the SDGs provide compared to other studies that have tried to connect them. Secondly, whether differences have been observed in the results based on the language of the chosen text, and what could be the reasons for this. Thirdly, a proposal is set out for how these results can be used practically to support decision makers.

4.1. Semantic network analysis vs expert-based analysis

Studies usually search the relationships of an SDG with the others determined by the disciplinary interests of the researchers. In this way Singh et al. (2018) in the Journal on Marine Policy studied the relationships between SDG 14 (on the protection of marine ecosystems) and the other goals. They used a panel of experts in different subjects; the relationships were scored using a scale to determine the extent to which they are connected. The results showed that SDG 14 was intricately linked to all other goals. Another similar study examined how SDG 6 (access to clean water and sanitation) affected the other goals (Hall et al., 2017). These researchers also used a similar scale with seven values, using a methodology already used by Nilsson et al. (2016). Their conclusion was that SDG 6 was also closely related to all other goals and that it needed the most improvement. Other studies also stand out, such as the one by Fuso Nerini et al. (2018), which finds that SDG 7 (sustainable energy) has a strong connection to the others, or Mc Collum et al. (2018), who show how the majority of the connections for SDG 7 and the other goals tend to be positive, that is, advances in sustainable energy brings with it advances in other goals. Interestingly, in our analysis this goal was the least connected. Our results show that the 17 goals form a semantic network in which no goal is separated from the rest, although the intensity of the relationship can vary, as shown in Fig. 2. As a result, any approximation based on a specific scientific discipline, as has occurred in previous studies, will always find relationships between one goal and another. Whilst this clearly does not invalidate these studies, and it is interesting to understand the connections in detail, the central bias in the experts' judgement prevents them from offering a holistic view of the interactions between SDGs. Even the interesting work of Le Blanc (2015) at the United Nations Department of Economic and Social Affairs, that used network analysis to connect all different SDGs and establish relationships between the targets of each of the goals and the goals themselves is determined by expert judgement. This is therefore a complex and expert view, although it could also include a certain amount of bias.

The starting point in this study is that the official documents containing the goals already incorporate the judgement of the experts who gained the global consensus and developed the goals and their targets. As a result, another layer of expert judgement is not added, but rather the aim is to extract the underlying criteria using semantic analysis tools. Therefore, we believe that the analysis carried out does a better job at clarifying the interactions between goals and provides clues, for example, of how to work with the SDGs when it comes to planning strategies, as discussed subsequently. The semantic analysis provides quantifiable results that complement the results from the analysis that has been carried out based on the experts' judgement.

4.2. Effects of language in the overall network of interactions between goals

When the degree centrality of the different SDGs is compared, differences between languages are observed, although there is a great

deal of consistency at the extremes, that is, between the 4 most connected goals and the 3 least connected goals.

If we examine the most connected goals, SDG 2 (zero hunger and sustainable agriculture), SDG 8 (decent work and economic growth), SDG 12 (responsible consumption and production) and SDG 11 (sustainable cities and communities) appear in both languages. We can find studies that are in agreement with regards to the importance of these goals. Therefore, in relation to SDG 2, the researchers involved in the Eat Stockholm Food Forum, indicate that this goal was the development centre and the others revolved around it (Gordon et al., 2017; Rockström and Sukhdev, 2016). It still makes sense that the fight to eradicate hunger and achieve adequate access to food, which has historically driven international initiatives and was the first of the Millennium Development Goals, maintains a crucial role. Moreover, with regards to SDG 8, Poschen (2015) explains in his book how decent work can significantly contribute to achieving the SDGs' agenda. In terms of SDG 12, there are a few studies that agree that it is a cross-functional goal that affects the others (Gunawan et al., 2020; Koide and Akenji, 2017), even though governments are not sufficiently integrating it when creating their policies. These last two goals also appear amongst the most connected goals in the study by Le Blanc (2015). With regard to SDG 11, its goals are focused on improving basic services and infrastructure in cities with an environmental focus. The fact that more than half of the world's population lives in cities and this figure is increasing, offers a clue to the importance of this objective in sustainable development (Bibri et al., 2020). The United Nations Urban Agenda recognizes the correlation between good urbanization and sustainable development, which requires synergistic and simultaneous measures in several sectors (United Nations-Habitat, 2017).

SDG 15 is highly connected only in the English text, and since we did not find studies that support its high connection, we consider that it is a result generated by the effect of language. Another result that stands out is the presence of SDG 17 (partnerships for the goals) as the most connected in Spanish, whilst it is in an average position in the ranking in English. For the Stockholm Resilience Centre (Rockström and Sukhdev, 2016), SDG 17 falls outside of their proposed classification, that is, it is a goal that falls outside of the economic, social or environmental ones, and instead works for the other goals in a cross-functional manner. This could be consistent with its high level of connection in Spanish, but if that were the case it should be the same in English. As indicated in the results, the explanation is that in Spanish the description of such a cross-functional goal involves a large number of generic words, which tend to be fewer in the English language.

If we now turn our attention to the group of goals with the least degree centrality or weaker connections to the others, these are: affordable and clean energy (SDG 7), peace, justice and strong institutions (SDG 16) and climate action (SDG 13). Their positions are practically the same in all the methods. The explanation could be because their texts are shorter, although the results indicate that this is not the main reason: semi-specific words are those that connect goals and are exceedingly scarce within these goals.

When comparing these results with the least connected in the study by Le Blanc (2015), only SDG 7 coincides with our analysis. The technical specificity of the description of energy change towards sustainable sources appears to be the cause of this disconnect, which results in a lack of connection in the semantic network in relation to the rest. Interestingly, and as explained in the previous section, SDG 7 is for some authors, who analyse it using expert judgement, a goal with a high level of interconnectivity (Fuso Nerini et al., 2018; McCollum et al., 2018).

With regards to SDG 13, in its latest report (United Nations, 2020b) the UN has highlighted this as the goal that requires the most urgent attention, and there are previous studies to the SDGs that demonstrate the high extent to which sustainable development and climate change are connected (Beg, N; Morlot, JC; Davidson, 2002), although the lack of implementation in policies is also highlighted (Swarta et al., 2003).

Lastly, the presence of SDG 16 amongst the most disconnected also stands out, as good governance is the foundation for all good development policies and its importance for achieving the other goals is also recognized (Hope, 2020). However, there is not a single study that specifically evaluates this goal's interactions with the rest, and it can only be considered that in a similar way to SDG 13, they are cross-functional goals whose actions are set out in other goals.

In conclusion, we can see how the semantic analysis shows that there is significant linguistic consensus in the extremes and less in the wider intermediate group, but above all, the idiomatic aspect can influence the interpretation of the overall network of goals. Although this overall network maintains its connection, the linguistic nuances can influence the relative importance amongst the SDGs, and this can have an impact when it comes to targeting efforts and policies, as we will see in the following section, and also when it comes to raising awareness of the SDGs amongst citizens. Incorporating this type of semantic analysis in the translation of these texts could help to homogenise them in an iterative process. We have dealt with two languages, but the United Nations has six official languages and the European Union, for example, has 24 official languages. There is still a large area to delve into in terms of the influence that language has, even at a subnational level.

4.3. Application in sustainable development policies

Once the results have been understood, and some limitations due to language identified, it is important to present a practical application of this analysis for national policies. Most countries have voluntarily presented reports on their progress with SDGs at the High-level Political Forum on Sustainable Development (HLPF) during the initial years of implementation (United Nations, 2020a). As SDG situations are different in each country, their policies are also different. Each country is working towards these goals based on their own specific development needs. Developing countries are focusing on reducing poverty and hunger, and ensuring access to water, whereas developed countries are focusing more on improving governance, improving gender equality, or improving the environment. However, although these policies are based on the specific goals that are deemed a priority for each country, they will end up indirectly affecting other goals.

Before applying this analysis, it is necessary for planners to identify the goals that are the priorities for sustainable development in their country. Based on Fig. 2, it is possible to identify the priority goals that are most connected and represent this network to identify

the specific connections for each goal. To show how this study can be applied to development policies we use two examples: Nigeria and Spain. The priority goals network facilitates the analysis of different paths and determines how to achieve these goals.

Nigeria is a developing country and uses the English language, and its priority goals are defined in the SDG Voluntary Review Report (Nigeria Government, 2020). This country is focused on the key issues of poverty (SDG 1), an inclusive economy (SDG 8), health and wellbeing (SDG 3), Education (SDG 4), Gender equality (SDG 5), the enabling environment of peace and security (SDG 16), and partnerships (SDG 17). If we take the English network in Fig. 2 and we only leave the seven goals that Nigeria has selected as priorities, we can more clearly see the interactions between them (Fig. 3). Different routes can be traced to achieve all the objectives that have been prioritised. The most strongly connected goals are 8 and 17. Therefore, their policies should emphasise these goals to help the others.

Spain is a developed country, obviously uses the Spanish language, and its priority SDGs are defined in the SDG Voluntary Review Report (Spanish Government, 2018). Advances in Spain are focused on improving governance (SDG 16), the inclusion of a majority of women in government groups (SDG 5), and the creation of a 2030 Agenda Commissioner and a High Commissioner for Child Poverty (SDG 1). The Ministry for Ecological Transition has also been created, bringing together expertise in energy (ODS 7), the environment (ODS 11, 12, 14, 15), and climate change (ODS 13), and the Ministry of Equality has also been reinstated (SDG 10). In Spain (Fig. 4), the most strongly connected objective is 12, followed by 11, 15, and 14. Therefore, these would be the objectives from which routes can be drawn to reach the others. For example, a strong drive from the work in SDG 12 could contribute to improvements in SDG 11, 14 and 15. Goals 7, 13 and 16 have a weaker connection to 12 and, as previously mentioned, would need to work with them in a specific manner.

In their renowned works on psycholinguistics, Quillian & Collins (Collins and Loftus, 1975; Collins and Quillian, 1969), state that a semantic network is a linguistic representation of knowledge. In this case, the representation of knowledge that is in the SDG texts, and it can be observed how some knowledge is highly connected and other knowledge appears to be more isolated. Therefore, it is possible that some of the SDGs may require direct, explicit and clear attention as they will not have the opportunity to be subsidiarily enriched by the stimulus that the others receive. Decision makers should take this into account when it comes to balancing their efforts during the implementation of policies. The above two examples provide an idea of how these graphs could be applied, although each case should be studied carefully and the paths between nodes should be interpreted correctly, thereby providing options for their application.

5. Conclusions

The official SDG documents that were analysed in this article form a diverse collection that gathers experts' consensual knowledge, and herein lies the interest in analysing them. It is based on these documents that the overall concept of Sustainable Development is hoped to be transmitted to the planners in every country. This is why we have carried out a semantic analysis of these official documents, as an objective tool for analysing what the interactions between them are. The semantic analysis of the official documents aims

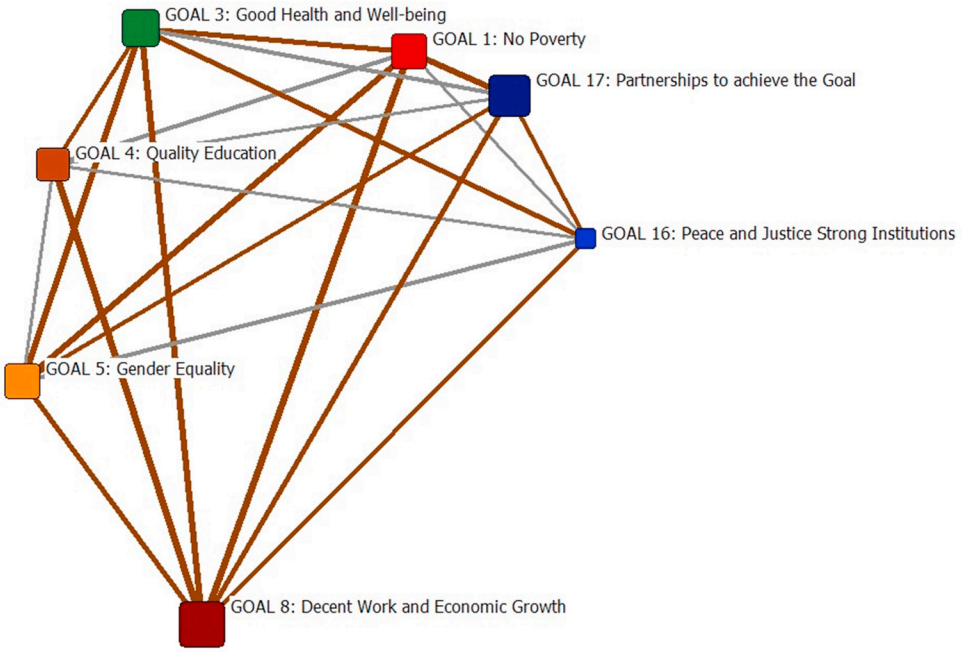

Fig. 3. Priority goals network in Nigeria with method 1 in English.

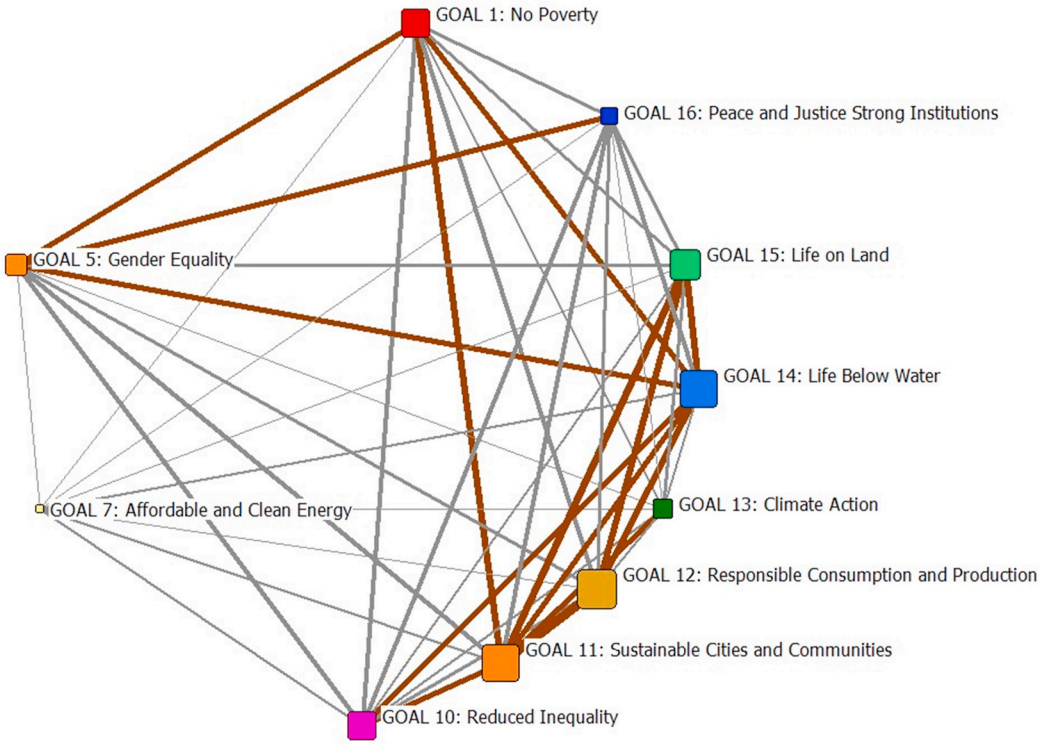

Fig. 4. Priority goals network in Spain with method 1 in Spanish.

to eliminate perception biases from experts' judgement, creating a network of relationships between goals that is quantifiable and objective. Furthermore, despite the large number of studies on SDGs, there has not previously been a quantitative semantic analysis regarding these goals. This type of analysis can be used to analyse other documents relating to the SDGs, which could help to identify the type of underlying relationships they have so that efforts and policies can be better targeted towards achieving said goals.

The network of interactions shows that each goal is connected with the other 16 goals. However, the intensity of the connection does vary and the results show differences between the languages. Nevertheless, there are a group of goals that are always well connected to the others and these could be known as driving forces: this higher level of connection means that their progress drives the others forward. These goals are SDG 2 (zero hunger), SDG 8 (decent work and economic growth), SDG 12 (responsible consumption and production) and SDG 11 (sustainable cities and communities). There are also a group of goals that are least connected, SDG 7 (affordable and clean energy), SDG 13 (climate action), and SDG 16 (peace, justice and strong institutions). These goals are transversal goals, and their lack of connection could be because they work independently or that they provide a basis for the rest of the goals. These goals are perhaps the most difficult in terms of transitioning from current to sustainable systems of governance and management, and that may be one reason why the texts are less connected. For this reason, we leave this line of research to future studies.

Language is critical for creating a discourse, as well as generating thinking and knowledge amongst its speakers. As a result, it would be necessary to observe how the structures of semantic relationships differ in the different versions of the SDGs in other languages, as there could be significant differences that influence the development plans.

The resulting network in this article can and tries to help visualise the connections between goals, to take them into account when it comes to planning and working in pursuit of achieving the SDGs. The analysis for the examples of Nigeria and Spain helps to show the application of the network between goals. However, a specific country or region has different mechanisms for deciding what its development priorities are, and then identifying the relevant SDGs that would best suit them. This study would be more complete if this network could be compared with other similar ones created based on the political programme and the local population's priorities which are identified through participative processes. Whoever the decision makers are, this analysis is a way of visualising what implicit interactions the SDGs have, both for the selection process as well as for proposing priority actions.

The Sustainable Development Goals proposed by the United Nations have achieved almost universal reach and consensus. Based on these, a large number of initiatives are being implemented. This article facilitates the analysis of these initiatives from a holistic perspective, so that all of the relationships that the initiative has with the group of SDGs can be considered. As a result, the analysis that has been set out in this study aims to help these initiatives to be more efficient and complementary to others that can equally facilitate the achievement of the SDGs.

Author statement

Fariña García M.C: Investigation, Conceptualization, Methodology, Data curation, Formal analysis, Visualization, Writing - Original Draft. De Nicolás De Nicolás V.L: Investigation, Supervision, Writing- Reviewing and Editing, Visualization. Yagüe Blanco J.L: Investigation,Supervision, Writing- Reviewing and Editing, Visualization; Labrador J.: Investigation, Supervision, Writing- Reviewing and Editing, Visualization.

Declaration of competing interest

The authors declare that they have no known competing financial interests or personal relationships that could have appeared to influence the work reported in this paper.

Annex 1. Sustainable Development Goals

- **Goal 1:** End poverty in all its forms everywhere
- **Goal 2:** End hunger, achieve food security and improved nutrition, and promote sustainable agriculture
- **Goal 3:** Ensure healthy lives and promote well-being for all at all ages
- **Goal 4:** Ensure inclusive and equitable quality education and promote lifelong learning opportunities for all
- **Goal 5:** Achieve gender equality and empower all women and girls
- **Goal 6:** Ensure availability and sustainable management of water and sanitation for all
- **Goal 7:** Ensure access to affordable, reliable, sustainable and modern energy for all
- **Goal 8:** Promote sustained, inclusive and sustainable economic growth, full and productive employment and decent work for all
- **Goal 9:** Build resilient infrastructure, promote inclusive and sustainable industrialization, and foster innovation
- **Goal 10:** Reduce income inequality within and among countries
- **Goal 11:** Make cities and human settlements inclusive, safe, resilient, and sustainable
- **Goal 12:** Ensure sustainable consumption and production patterns
- **Goal 13:** Take urgent action to combat climate change and its impacts by regulating emissions and promoting developments in renewable energy
- **Goal 14:** Conserve and sustainably use the oceans, seas and marine resources for sustainable development
- **Goal 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
- **Goal 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
- **Goal 17:** Strengthen the means of implementation and revitalize the global partnership for sustainable development

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