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Ágatha Lopes Tommasi Oliveira

Proposal of a systemic conceptual model to define a country's Agenda 2030: prioritization of global targets integrating multicriteria methods, structural analysis, and network theory

Master Dissertation

Dissertation presented to the Programa de Pós-Graduação em Metrologia (Área de concentração: Metrologia para Qualidade e Inovação), PUC-Rio as partial fulfillment of the requirements for the degree of Mestre em Metrologia.

Advisor: Prof. Rodrigo Flora Calili
Co-Advisor: Prof.ª Maria Fatima Ludovico de Almeida

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Prof. Rodrigo Flora Calili
Advisor
Programa de Pós-Graduação em Metrologia – PUC-Rio

Profª. Maria Fatima Ludovico de Almeida
Co-Advisor
Programa de Pós-Graduação em Metrologia – PUC-Rio

Prof. Reinaldo Castro Souza
Departamento em Engenharia Elétrica – PUC-Rio

Prof. José Francisco Moreira Pessanha
Centro de Pesquisas de Energia Elétrica – CEPEL

Márcio da Silveira Carvalho
Coordenador Setorial do Centro Técnico Científico - PUC-Rio

Rio de Janeiro, May 10th, 2018

Ágatha Lopes Tommasi Oliveira

Bachelor in Environmental Engineer, Pontifical Catholic University of Rio de Janeiro, 2018.

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To all children who will be born in 2030…

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Abstract

Agatha Lopes Tommasi Oliveira. **Proposal of a systemic conceptual model to define a country's Agenda 2030: prioritization of global targets integrating multicriteria methods, structural analysis, and network theory.** Rio de Janeiro, 2018. 111 p. Dissertação de Mestrado – Programa de Pós-Graduação em Metrologia, Pontifícia Universidade Católica do Rio de Janeiro.

A fundamental question in the implementation of the 2030 Agenda at the national level is how the Sustainable Development Goals (SDGs) and their respective targets interact with each other. Directly linked to this concern, a methodological question arises – how can the integration of multicriteria decision making methods, structural analysis, and network theory contribute to a country to better define which global targets should be included in its 2030 Agenda, considering critical issues of its socio-economic and political contexts. With an attempt to answer this question, the dissertation aims to propose a systemic conceptual model to prioritize SDG's targets for a country's 2030 Agenda, by integrating multicriteria decision methods, structural analysis, and network theory. The research can be considered descriptive, methodological and applied. Based on the results of the bibliographic review and documentary analysis of its central themes, and seeking to fill the gaps identified in the specialized literature, a systemic conceptual model was developed for prioritizing global targets that should be included in a country's 2030 Agenda, considering critical issues of its socio-economic and political contexts. The model's applicability was demonstrated through a preliminary experiment concerning the definition of the Brazilian 2030 Agenda. It is believed that the conceptual model resulting from this research can be replicated in other national contexts, particularly in countries where the It is believed that the conceptual model resulting from this research can be replicated in other national contexts, particularly in those countries that are going to prioritize the targets that will integrate their respective Agendas for Sustainable Development.

Keywords

Metrology; 2030 Agenda; Sustainable Development Goals; multicriteria decision-making methods; structural analysis; network theory.

Resumo

Agatha Lopes Tommasi Oliveira. **Proposta de um modelo conceitual sistêmico para definição da Agenda 2030 de um país: priorização de metas globais integrando métodos multicritério, análise estrutural e teoria de redes.** Rio de Janeiro, 2018. 111 p. Dissertação de Mestrado – Programa de Pós-Graduação em Metrologia, Pontifícia Universidade Católica do Rio de Janeiro.

Uma questão fundamental na implementação da Agenda 2030 em nível nacional refere-se à análise das interrelações entre os Objetivos de Desenvolvimento Sustentável (ODS) e como suas respectivas metas interagem entre si. Diretamente ligadas a essa análise, surge outra questão de ordem metodológica, qual seja: como a integração de métodos multicritério de tomada de decisão, análise estrutural e teoria de redes poderá contribuir para que um país possa melhor definir que metas globais deverão ser incluídas na sua Agenda 2030, considerando-se aspectos críticos de seus contextos socioeconômico e político. Buscando responder essa questão, a presente dissertação tem por objetivo propor um modelo conceitual sistêmico para priorizar metas globais associadas aos ODS que irão compor a Agenda 2030 de um país, integrando-se métodos multicritério de apoio à decisão, análise estrutural e teoria de redes. A pesquisa pode ser considerada descritiva, metodológica e aplicada. Com base nos resultados da revisão bibliográfica e da análise documental de seus temas centrais e visando preencher as lacunas identificadas na literatura, desenvolveu-se um modelo conceitual sistêmico para priorizar as metas globais a serem incluídas na Agenda 2030 de um país. A aplicabilidade do modelo foi demonstrada mediante um experimento preliminar no contexto da Agenda 2030 brasileira. Acredita-se que o modelo conceitual resultante desta pesquisa possa ser replicado em outros contextos nacionais, particularmente em países que estão para definir as metas que integrarão suas respectivas Agendas para o Desenvolvimento Sustentável.

Palavras-chave

Metrologia; Agenda 2030; Objetivos do Desenvolvimento Sustentável; métodos multicritério de apoio à decisão; análise estrutural; teoria de redes.

Summary

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1
Introduction

Humankind is faced with a unique moment in its history. It is imperative that we address significant challenges such as global climate change and the increasing probability of water scarcity. On the other hand, global connections and dialogue allow us to direct our common efforts towards solutions driven by justice, balance, and consciousness. At the present time, those big challenges can be tackled thanks to international cooperation, and the solutions need to be immediate. International agreements and the establishment of a global common agenda bring hope to this problem. Those efforts consist in joint-sector national polices, cooperation across nations, sharing of knowledge and efficient technologies, co-action of major stakeholders, shorting the science-policy gap, and many others.

Over the past few decades, “Sustainable Development” has become a more frequent presence in spaces of global dialogues such as International Conferences or Forums as well as the United Nations High Level Panel. For a long time, the speeches were motivated by growing concerns about resource security, then the focus was on preserving natural resources to guarantee human rights and welfare of future generations. However, the epistemological underpinnings of the concept started recently to consider the right of nature to exist for its own sake. The strong emergence of those conclusions in the early 21st century marks the expansion of consciousness of the human being. It is now recognized other species’ exist for reasons beyond merely providing a service to humans. In other words, consensus has formed around the necessity of fully preserving natural areas in the world, and along with it, to improve the restoration of depleted areas to guarantee the equilibrium of ecosystems.

Recently, a huge step was taken to bring humanity together to solve global and environmental issues with the proposal of the 2030 Agenda, which is an international holistic deliberative approach. It pushes high level decision makers to consciously harmonize their strategies of economic growth and reduction of social inequalities without interfering in the equilibrium of biodiversity needed to maintain life of Earth, contributing to Sustainable Development.

Most countries implement public policy through sectoral ministries: energy, environment, education, agriculture, etc. This focused vision is necessary to meet the needs of specialized competences. In contrast, those separate efforts make the establishment of joint agendas very challenging, which can often leads to contradictory actions (Nilsson, 2017). The understanding of trade-offs and synergies across sectors are still insufficient, which results in incoherent policies (Blanc, 2015). This reality makes even more challenging to increase the convergence of public policies with the SDGs.

Considering the lack of scientific works exploring the integration of multicriteria decision-making methods, structural analysis, and network theory for prioritizing the global targets that should be included in a country's 2030 Agenda, this dissertation aims to assist worldwide policy makers in pragmatically defining the priorities of this globally agreed-upon Agenda at the national level. It was carried on a documentary analysis focusing on national initiatives and efforts of achieving the Sustainable Development Goals by 2030, together with the scientific articles about the integration of SDGs and global targets interlinkages.

Based on the results of the bibliographic review and documentary analysis of its central themes, and seeking to fill the gaps identified in the specialized literature, a systemic conceptual model was developed for prioritizing global targets that should be included in a country's 2030 Agenda, considering critical issues of its socio-economic and political contexts This model allows to prioritize global targets associated with a country's SDGs, by integrating multicriteria decision-making methods, structural analysis, and network analysis.

1.1. Definition of the research question

Before stating the research question and objectives, a few reflections upon the basis for formulation are provided. The research is based on the following assumptions:

- It is imperative to analyze all interactions among SDGs and their associated global targets for establishing a country's 2030 Agenda;
- The importance of improving current practices related to the prioritization of global targets at the national level for defining a country's 2030 Agenda, from the perspective of increasing the policy coherence to the targets' implementation;

- Due to the complexity, transversality and uncertainty inherent to the prioritization process of the global targets at the national level, countries can benefit from a conceptual model that integrates multicriteria decision-making methods, structural analysis, and network theory;
- The lack of scientific articles exploring the integration of different methodological approaches opened a research space for exploring the combination of the above mentioned methods;
- Brazil created the National Commission for the Sustainable Development Goals (acronym in Portuguese, CNODS) and is in the process of setting its 2030 Agenda.

The overall quest of this research could be formulated as follows:

"How can the integration of multicriteria decision making methods, structural analysis, and network theory contribute to a country to better define which global targets should be included in its 2030 Agenda, considering critical issues of its socio-economic and political context?".

1.2. General and specific objectives

With an attempt to answer the research question, this dissertation aims to propose a systematic conceptual model to prioritize the global targets associated to SDGs at the national level, by integrating multicriteria decision-making methods, structural analysis, and network theory.

This general objective can be broken down to five more specific objectives that would together achieve the overall goal of the research as follows:

- To understand the interactions between the SDGs and associated targets at the national level, using the scale proposed by Nilsson *et al.* (2016);
- To identify the reference works and methodological approaches with potential to be combined to prioritize global targets associated to the SDGs, which will be part of a country's 2030 Agenda;
- To define criteria for prioritizing the global targets at the national level;

- To develop a systemic conceptual model for prioritizing the global targets associated to the SDGs at the national level, in order to establish a country's 2030 Agenda;
- To demonstrate the applicability of the proposed model in Brazil, through a preliminary academic experiment concerning the prioritization of the global targets that should be included in its 2030 Agenda.

1.3. Motivation

The motivation of proposing a systemic conceptual model to prioritize the key global targets at the national level is directly linked to the potential applicability of this model in other national contexts, particularly in those countries that are going to prioritize the targets that will integrate their respective Agendas for Sustainable Development.

It is also believed that the improvement of the current practices related to the prioritization of global targets at the national level could increase the country's policy coherence to the targets' implementation within the scope of its 2030 Agenda.

1.4. Research methodology

The research can be considered descriptive, methodological and applied. The methodology adopted during its development encompasses three distinct phases: (i) exploratory and descriptive; (ii) applied research, focusing on a preliminary academic experiment; and (iii) conclusive.

The next sections correspond respectively with the description of these phases.

1.4.1. Exploratory and descriptive phase

The exploratory and descriptive phase was initiated with bibliographical review and documental analysis covering the period of 2015- 2018, with the purpose of constructing the theoretical and normative background for the delimitation of the central theme of this research. In this phase, reference works

and methodological approaches adopted in empirical works were reviewed, from the perspective of improving the tools and methods currently employed to understand the interactions between the global targets and also between SDGs at the national level. Besides, methods used to prioritize the global targets at the national level, according to the experiences of some countries reported in the literature were also reviewed for the purpose of this research.

The theoretical framework was a conceptual orientation for the research, helping to compose the specialized vocabulary and to organize the knowledge on the main subjects of this research. In fact, the literature review and documental analysis evidenced that the prioritization of global targets is an initial and critical step to implement the 2030 Agenda at the national level. In addition, exploring voluntary reports provided by countries illustrated that governments have been prioritizing targets with support of a basic cross-impact and network analysis.

These findings evidenced a lack in the literature to be investigated by this research, i.e. the integration of multicriteria decision-making methods with fuzzy logic to select the key targets in a first stage; afterwards, the use of structural analysis, as proposed by Godet (1994), with the scale established by Nilsson *et al.* (2016a; 2016b); and finally, the network analysis for better visualization of the targets' interactions obtained by the structural analysis.

1.4.2. Applied phase

In this phase, a systemic conceptual model was developed, by integrating multicriteria methods (fuzzy AHP-TOPSIS), structural analysis, and network theory. The model will be reported in chapter 4. Finally, the applicability of the proposed model could be demonstrated in a Brazilian context, through an preliminary experiment designed to test the new methodological approach, rather than to effectively prioritize global targets for the 2030 Agenda and discuss the final results.

1.4.3. Conclusive phase

The general and specific conclusions were elaborated in relation to each one of the objectives posed in section 1.2. Also, a set of recommendations was formulated to the various stakeholders interested in the application of the systemic conceptual model as proposed in this research.

1.5.
Structure of the dissertation

This dissertation is structured in six chapters. While this first one has an introductory character, the second one is focused on presenting the Sustainable Development Goals (SDGs), along with the literature focused on the imperative of understanding the interactions between SDGs and between their global targets.

The third chapter discusses some countries' experiences in implementing their 2030 Agendas. It goes far to the investigation of literature gaps regarding the global target's prioritizing at the national level.

In the chapter four, a systemic conceptual model is proposed to help countries to prioritize global targets, considering critical issues of their socioeconomic and political contexts. And finally, the chapter five reports the findings of a preliminary experiment developed to test the applicability of the model in the Brazilian context.

The sixth chapter is dedicated to present conclusions as well as recommendations for stakeholders interested in apply the conceptual at national level, and also suggestions for future works.

2
The 2030 Agenda: a global agreement towards sustainable development

Before going any further, this chapter aims to introduce the object that drove this research: the 2030 Agenda. Then, the section 2.1 presents the generation of this Agenda and the section 2.2. shows a literature analysis that revealed multiple ways of interpreting and reading it.

2.1.
Introducing the Sustainable Development Goals (SDGs)

In September 2015, the United Nations (UN) spearheaded a set of seventeen "Sustainable Goals"(figure 2.1) integrated in a global development agenda which has a time horizon of 2015 to 2030 (A/RES/70/1). This adopted resolution, named Transforming our world: the 2030 Agenda for Sustainable Development, sets a strong message that its implementation relies on collaborative action between all countries and all stakeholders. The Goals main purpose is to guide national governments to implement policies that strengthen the pathway toward a "green" economic growth. The countdown to achieving these Goals began on January 1st, 2016 (O' Connor *et al.,* 2016).

Figure 2.1 - Sustainable Development Goals
Source: United Nations (2015).

Due to its multidimensional view on development, the 2030 Agenda contrasts to other conventional development agendas focused on a restricted set of dimensions (Pradhan *et al.,*2017) and it gives further impetus to the dialogues between the multiple sectors of policy-making (Boas *et al.,* 2016). Hence, they address emerging challenges (Sachs, 2012) with the objective to cover the whole sustainable development universe (Blanc, 2015). By tackling multiple challenges that humankind is facing, the Sustainable Development Goals (SDGs) aim to close the gaps left by the Millennium Development Goals (MDGs) framework (Sachs, 2012) and intend to strengthen universal peace in larger freedom through its plan for people, planet and prosperity. Different from the MDGs, the seventeen SDGs were defined through a bottom-up approach, which started in the Rio + 20 conference held in 2012.

Each one of those 17 Goals contains a range of targets (See Annex 1) and each target is accompanied by at least one indicator. Even though the UN has established 231 indicators, not all of them have a well-developed. In fact, they are divided in to three "tiers" of indicators (Sachs *et al*., 2016):

- Tier I - the methodology is agreed and data are already widely available
- Tier II - the methodology is agreed but the data are not widely available
- Tier III - the methodology is still not globally agreed

The set of SDGs is based on the importance of interdependencies, interactions and linkages of the development multi-dimensions; having a global agreement on this framework represents a turning point towards a new paradigm for global development policy and cooperation.

The next section delves into this nexus approach in the 2030 Agenda for Sustainable Development; it analyses how the associated targets communicate amongst themselves.

2.2. SDGs are an "indivisible" whole

The goals have boosted academic and political debates about how to best address the nexus between the multiple sectors, recognizing that each SDG can't be reached in isolation from the others, they are intensely interdependent (O'Connor *et* al., 2016; Nilsson, 2017; Boas *et al*., 2016; Blanc, 2015).

This interrelation is obvious in their 169 associated targets that address the necessity of multi-sectors efforts. Due to this, the 2030 Agenda is recognized as an integrated, “indivisible” whole.

Characterizing intrinsic linkages between the highly multidimensional SDGs in particular is complicated since the majority of interrelations need to be evaluated at the level of the 169 targets. By analyzing the wording content of each target, it is possible to identify explicit linkages (Le Blanc, 2015). If those wording linkages are further explored in the documents of the UN system, it is possible to find even more dependences that reflect the results of negotiations in an intergovernmental context. This was demonstrated in one approach, published by Vladimirova *et al.* (2016), who made an investigation focused on the SDG 4 (related to education) and its multiple interlinkages. Such studies highlight trade-offs and synergies, showing interdependencies between two or more issues that need to be tackled in an integrated way (Griggs *et al.,* 2014).

Although it is already a common knowledge that the 169 target under the 17 SDGs are integrated and indivisible (Sachs *et al.,* 2016), the intensity of those connections are still foggy, which brings a large field for investigation. Going further than simple link identification, a Stakeholder Forum study analyzed the links of the targets under the Sustainable Consumption and Production (SCP) goal with other targets (Coopman *et al.,* 2016).

The applied approach has divided the SCP thematic in eight sub-categories under three categories: supporting (commonly supporting and mutually supporting); Enabling (disenabling; direct enabling in both directions; direct enabling and indirect enabling); Relying (partial reliance and full reliance). The outcomes from this exercise consisted in key finds and recommendations to the European Union (EU) such as to harness the Circular Economy proposals or to strengthen the call for more ambitious green economy schemes.

Another study that took into account the importance of investigating the deepness of the relations between targets was carried out by Weitz *et al*. (2014). The study has explored the nature of interaction of targets in order to have a starting point for visualizing a more integrated approach. Intrinsic links between the water, energy and food SDGs were investigated through a three-point typology: interdependence; imposing conditions or constraints; and reinforcing (Weitz *etal.*, 2014). Some relations at goal level with health, education and industrial development areas were also recognized.

Afterwards, Nilsson *et al.* (2016a) went deeper in the investigation of the existence of “trade-offs” and “synergies”, which can be beneficial, adverse or

"neutral". It proposed a seven-pointed typology (Table 2.1) that scores the degree of interdependency at target level and aims to encourage cross-sectoral and cross-disciplinary conversations. Such interactions need to be assessed at the target level, and they show that interactions between targets are not necessarily positive, but can sometimes have a negative impact (Nilsson *et al.* 2016b).

Table 2.1 Seven point typology of SDG interactions

Interaction	**Description**
Indivisible (+3)	The strongest form of positive interaction in which one objective is inextricably linked to the achievement of another.
Reinforcing (+2)	One objective directly creates conditions that lead to the achievement of another objective.
Enabling (+1)	The pursuit of one objective enables the achievement of another objective.
Consistent (0)	A neutral relationship where one objective does not significantly interact with another or where interactions are deemed to be neither positive nor negative.
Constraining (-1)	A mild form of negative interaction when the pursuit of one objective sets a condition or a constraint on the achievement of another.
Counteracting (-2)	The pursuit of one objective counteracts another objective.
Cancelling (-3)	The most negative interaction is where progress in one goal makes it impossible to reach another goal and possibly leads to a deteriorating state of the second.

Source: Nilsson *et al.* (2016b); Nilsson *et al.* (2017).

This proposed scale takes a direct interaction between two targets. It shows how one target can influence another and whether this influence is positive, negative or insignificant. Evaluating this influence requires a lot of comprehension of the country or local context, since this analysis can be very subjective.

In one analysis published by ICSU in 2017, it is discussed about possibilities of interactions. Some interactions can mutually influence each other as it happens between the targets 14.2,14.5 and 8.1,8.3. The adoption of measures to restore and protect marine and coastal ecosystems (14.2, 14.5: Annex 1) leads the regulation of local fishery or logistic activities, which might mean restrictions for economic activities and therefore limit opportunities for job creation and economic growth and (8.1,8.3: Annex 1) (ICSU , 2017). On the other hand, simply creating

job opportunities to stimulate economic growth can accelerate damage in costal and marine ecosystem; therefore, both targets counteract each other. However, if the interrelations between the SDG 14 and SDG 8 are analyzed, it is possible to conclude that the targets 14.4,14.7 and the targets 8.1,8.5reinforce each other. The implementation of sustainable marine activities such as sustainable aquaculture, fisheries and tourism (targets 14.4, 14.7: Annex 1) stimulates the economy through creating sustainable job opportunities and achieving full employment (targets 8.1,8.5: Annex 1) and vice versa (ICSU , 2017).

Sometimes, the success of one target can be a pre-condition to achieve the success on another; this kind of interaction should be considered indivisible. For example, to achieve all necessary reductions in carbon emissions and air pollution (target 3.9: Annex 1) it is necessary to implement several actions. One of them is improving the efficiency of public transport as well as the cycling networks (target 11.2: Annex 1); this makes 11.2 indivisible from 3.9 (ICSU , 2017). However, the target 3.9 does not influence 11.2 neither positively nor negatively, then they have a neutral or consistent relation. This example has illustrated that two targets can differently influence each other, because of that, it is always important to analyze both directions of interactions. The influence is not necessarily strong; working on one specific target can slightly contribute to another one. For example, if the agricultural sector adopts more sustainable practices (target 2.4: Annex 1), the pollution will be consequently reduced and then the water quality improved (target 6.3: Annex 1) (ICSU , 2017). Then, the target 2.4 enables the target 6.3.

Unfortunately, as the example between the targets 14.2,14.5 and 8.1,8.3 illustrated in the beginning of this sections, not all influences are positive. A plan to achieve one target can constrain the plan to achieve another, or even worse, it can cancel. If, for example, the agricultural productivity is doubled (target 2.3: Annex 1) with the help of agro-toxins, the target 3.9 will be constrained because people will be exposed to hazardous chemicals (target 3.9 Annex 1) (ICSU , 2017). Moreover, the target 9.1 regarding developing infrastructure (Annex 1) can cancelling the reduction of degradation of natural habitats in terrestrial ecosystems (target 15.1: Annex 1) (ICSU , 2017).

Those presented possible negative consequences illustrate rebound effect of attempts to achieve development; a political strategy applied to one sector can undermine a policy goal in another one. Understanding these interactions brings the opportunity to forecast unfavorable impacts, and then to implement policy by taking into account ways to minimize possible damages, once they are no longer unexpected (Nilsson, 2016a).

On the other hand, the identification of key interlinking targets that operate as connectors or enablers is important to the development of political strategies across sectors. Moreover, the map of those positive interactions allows the comprehension of the cases when the achievement of one objective depends on the simultaneous or even preliminary action on others. The dynamics of interactions between targets will be different depending on the contexts (natural resources base, governance arrangements, availability of technologies, etc.) (Nilsson *et al.*, 2016b).

2.3. Final remarks on the chapter

This chapter synthesized the 2030 Agenda content and evidenced the multiple scientific efforts to comprehend the interactions at the targets level and their limitations and potentialities. All of those aspects were necessaries to characterize the thematic of interest of this research. Also, the analysis of SDGs interactions need to respect its national context.

In the next chapter the challenges faced by national policymakers of implementing this indivisible agenda and achieving progress across the economic, social and environmental dimensions of sustainable development will be discussed. Policy makers need to understand that different issue areas are intrinsically interconnected and must thus be governed as such.

In addition, the next chapter intends to identify the reference works and methodologies with potential to hierarchize the targets associated to the SDGs.

3
Implementing the 2030 Agenda at the national level: challenges and recommendations

The previous chapter presented the intensity and complexity of the multiple connections that the targets have among themselves. However, the question of how to better hierarchize those targets for the implementation of the Agenda at National Level remains. This chapter aims to search in the literature the efforts of national governments to implement the SDGs in their respective agendas as well as the mathematical tools already used to treat Sustainable Development. Through this identification, this chapter will analyze the most suitable ones to hierarchize the targets associated to the SDGs in the context of a country.

While the section 3.1. presents the recommendations provided by the UN, the section 3.2. illustrates some the efforts made by the national governments with the objective of identifying methods to implement. After that, the third section of this chapter brings a review of mathematical tools related to Sustainable Development Finally, the last section with the remarks of the chapter identifies the most interesting and useful tools presented in the chapter.reading it.

3.1.
Recommendations to policy makers

As the main purpose of the 2030 Agenda is to guide policy makers to have more conscious and precisely efforts regarding Sustainable Development, the UN specialists have established some proceedings to national governments.

Both of them are accompanied with guides, one to support national stakeholders in tailoring the 2030 Agenda to national context (UNDG, 2015; 2017) and the other to give directions to monitor national performance. UN will provide coordinated support to the countries by adopting a common approach under the acronym MAPS – Mainstream Acceleration Policy Support:, as follows:

- Mainstream: Landing the SDGs into national, sub-national and local plans for development, and shaping budget allocation;
- Acceleration: Targeting resources at priority areas, paying attention to synergies and trade-offs, bottlenecks, partnerships, measurement;

- Policy Support: Ensuring that skills and expertise of the UN Development System are available in an efficient and timely way.

Moreover, the UN recommends to implement the 2030 Agenda following eight Implementation Guidance Areas, grouped according to the PDC (Plan, Do, Check) strategy (Table 3.1). The three first steps correspond to the "Plan" phase, which includes public campaigns, stakeholder's engagement, reviewing existing national strategies and setting national relevant targets. This phase is focused on creating the best possible strategy to address the SDGs; comparing the ongoing national programs to the SDGs targets is a fundamental step. It is impossible to determine what needs to be done, without recognizing and understanding what has already been carried on. Still from this perspective, it needs to be pondered if it is smarter to keep the program, improving the program or creating a brand new one. The map of these possible matches is going to give a good basis to the exercise of setting national relevant targets, and once they are identified, it is possible to move to the "Do" phase, which embraces the next 3 steps. Now that the national scenario in relation to the 2030 Agenda is well understood, the policies and strategies can be designed along with the monitoring indicators. The UN has provided a set of global indicators (Sachs *et al.*, 2016), some have already a well-defined methodology (see section 2.1.), but the countries are very encouraged to also use its own milestones. Finally, the "Check phase", illustrated by the last two steps is dedicated to collect data and run the indicators.

Table 3.1 - UN Guidance: Implementing the 2030 Agenda at the national level

Steps to the implementation	
1	Raising public awareness
2	Applying multi-stakeholder approaches
3	Tailoring SDGs to national, sub-national and local contexts
4	Creating horizontal policy coherence (breaking the silos)
5	Creating vertical policy coherence ("glocalizing[1]" the Agenda)
6	Budgeting for the future
7	Monitoring, Reporting and accountability
8	Accessing risks and fostering adaptability

Source: UNDG (2015; 2017).

[1]According to the Encyclopædia Britannica, it is the simultaneous occurrence of both universalizing and particularizing tendencies in contemporary social, political, and economic systems

It is important to highlight that the toolkits provided by UN do not take into account any mathematic method to setting national relevant targets, which opens a dangerous space to the use of intuitive prioritizing. The jeopardy states in the intuitive prioritizing of target, which can constrain the effectiveness. Normally the policy makers tend to incorporate the interests of its party or the largest amount of interests, in a typical political game. Their choices need to deal with the higher dimensions of the system: hidden interests, social participation, constraints imposed by different cultures and power political relations; all of those stakeholders might affect the possible outcomes (Munda, 2009).

However, a best decision or a best setting of priorities not necessarily will be the one that attend the interests. Making a decision in a multidimensional area such as Sustainable Development is very challenging especially because sometimes the addressed problems might not be solved with direct actions on this addressed problem. In other words, the identified problem can be an element of a larger system, which makes this identified problem only an element, condition or symptom of either a bigger matter or of another issue (Martin, 2015).

The matters that have key roles to Sustainable Development need to be addressed through an strategy that bring into evidence the linkages between issues as well as the relevance of the initial problem statement in an effort to establish logical boundaries on the problem and to recognize all relevant interconnected elements (Martin, 2015). This shows that such targets with a multi-dimension embracement need to be treated with a mathematical model that considers several important aspects and diminish the possibility of a tendentious choice. Even though, mathematical approaches are not going to resolve all conflicts, they can help to provide a larger view of the systemic information (Munda, 2009).

Since there is no unique approach to all types of decisions, the best decision strategy to be used will depend on different factors such as the possible negative consequences, the level of complexity of the faced situation, time pressure and the experience and training of the decision maker(s) (Hersh, 1999). Multicriteria methods are very suitable in empirically aiding public policy and project makers because it takes into account a wide range of assessment criteria (Munda, 2009). Multicriteria Decision Methods (MCDM), with the use of proper indicators and adequate criteria, can help to structure the problem and increase understanding by clarifying the conditions to be satisfied (Hersh, 1999). Then it is possible to

conclude that MCDM or simply multicriteria methods can be an interesting tool to aid the setting targets to be prioritized in the implementation of the 2030 Agenda.

During the past two years, the scientific community endeavored to interpret the 2030 Agenda, to explore the consequences of the SDGs interactions and to recommend actions to policy makers. Among those strivings, it is included a guide about how to implement the seven-pointed typology (see section 2.2) (Nilsson *et al.,* 2016b) at the national level. The methodology to the goals 2,3,7 and 14 have highlighted key interactions that are essential to be taken into awareness (ICSU , 2017).

In parallel, another contribution regarding this scientific method has been delivered. In 2017, Nilsson and other scientists took the opportunity to push discussions about the needed integrated approaches to the implementation of the 2030 Agenda. Before the High-Level Political Forum 2017 (see section 3.3), they have done the exercise of applying the seven-pointed typology (Nilsson *et al.*2016b) to measure the interactions of the six goals in focus: 1,2,3,5,9 and 14 (Nilsson, 2017).

Those reports brought up some advices that need to be considered by policy makers, in order to have a successful implementation of the 2030 Agenda at national level. They argue the first step need to be a systemic identification of the interactions between the Goals - or even better if the associated targets - to setting priorities of implementation in a given context; this move consists in the disposing of the 17 Goals in a matrix form, where each intersection is scored with the seven-pointed scale (ICSU , 2017).

Once this matrix or map of interactions is built, the decision makers will be provided not only with a useful overview of key interfaces between Goals, but also with warnings of early identification of potential conflicts. This map will supply the government departments with subsides to the better implement joint actions across different sectors.

3.2.
National efforts towards the implementation of the 2030 Agenda

During the High Level Political Forum (HLPF) on Sustainable Development – a meeting under the auspices of Economic and Social Council (ECOSOC) – that was held in July of 2015, it was discussed how to best implement, communicate and review the post-2015 development agenda, which would be adopted in September 2015 (the 2030 Agenda, see section 2.1) (Sajdik, 2015). After that, the

following HLPFs (Table 3.2) would be dedicated to review national strategies of implementation, in order to guarantee that all committed countries are aligned and moving on with their respective action plans. The objective of the stimulation of those voluntary reviews and reports is to offer an opportunity of sharing experiences (successes, challenges and lessons learned) among nations, at a global level, thereby accelerating the implementation of the 2030 Agenda and mobilizing multi-stakeholder partnerships. In fact, these meetings aim to explore how far the governments have gone in ensuring their instructions are enough prepared to implement coherent plans and policies. (Nilsson *et a*l., 2016a).

In the HLPF of 2016, 22 countries have presented either a full report or an executive summary; even though there was a guideline suggesting the main elements those reports should have, the way their contents were presented varied a lot (DESA and DSD, 2016). Later, in 2017, 43 countries presented their national voluntary reviews (including Togo, presenting its second review already, and others promised to present in the next HLPFs (UN, 2018; DESA and DSD, 2017).

Since there is no uniform way of reporting on SDG-specific implementation in the Voluntary National Reviews (VNRs), the countries were free to choose their own methodology and priorities. While some countries have addressed all the SDGs along with a part of their plans to the implementation at a national level, others (the majority) have covered only the set of goals related to the 2017 High Level Political Forum (HLPF) thematic, as shown in table 3.2 , Brazil was one of those (DESA and DSD, 2017).

Table 3.2- HLPF meetings to discuss the implementation of the 2030 Agenda

High-Level Political Forum on Sustainable Development		
Year	**Thematic**	**Revised Goals**
2015	Strengthening integration, implementation and review – the HLPF after 2015	
2016	Ensuring that no one is left behind	
2017	Eradicating poverty and promoting prosperity in a changing world	1, 2, 3, 5, 9, 14, 17
2018	Transformation towards sustainable and resilient societies	6,7,11,12,15,17
2019	Eradicating poverty and promoting prosperity in a changing world	4,8,10,13,16,17

Source: UN, 2018.

According to the 2016 and 2017 Synthesis Report of the Voluntary National Reviews (DESA and DSD, 2016, 2017), some countries have started to setting national relevant targets, however those synthesis reports have not brought out any usage of mathematical methodology to this process. Going through non-exhaustively to some national reports, it was not identified any aid of a multicriteria methods to setting priorities to the targets.

However, it was found in the literature an example of scientific efforts relating the multicriteria and the SDGs (Khalifah *et al.,* 2017). In Indonesia, they have used of Analytic Network Process (ANP) to prioritize programs that have been carried on in the country. This approach provided a framework that can identify the relevance of 7 important rolling programs in the country according to the SDGs and vice-versa, which means to prioritize the SDGs according to those programs (Khalifah *et al.,* 2017). Even though the authors decided not to go deep into the targets level, they have done a great step in showing that the 2030 Agenda can be treated with multicriteria tools.

After the 2017 HLPF, some countries were still publishing their reports. Ukraine was among them; the country published (15th September 2017) remarkable scientific efforts of correlating government strategies and public policy with the SDGs (Horokhovets *et al.,* 2017). Their strategy was to identify which targets were already covered by national programs (and by how many); by investigating this, it was possible to recognize which targets were more political addressed and which weren't at all addressed.

Meanwhile in Sweden, the researchers were applying a seven-pointed typology (Nilsson *et al.* 2016a)(already presented in the section 2.2 of this research) on a set of 34 targets in the national context, with the focus on the measurement of the interconnections between each pair of the SDG selected targets (Weitz *et al.,* 2017). They selected two targets per goal according to their relevance to the national context, but the authors have not specified the methodology or criteria of the selection. The 34 targets were treated through a cross-impact matrix method and if that systemic effects are well understood,a good basis to the establishment of holistic polices at government level will be provided.

The implementation is not an easy process, it is indeed a very complex one, especially because of the several interactions and impacts between targets and goals. This shows the importance of science in assisting policy development. For example, the application of mathematical methods to analyse the synergy across different sectors as well as the SDGs are essential to identifying rippling effects.

Another huge challenge faced by the government is the allocation of a limited budget to competing priorities, especially when those priorities do not have a clear and agreed process of definition. In addition, most governments are not effectively organized to deal with multi-sectorial issues such as the ones addressed by the SDGs.

This section concluded that multicriteria methods can be an important tool in the process of implementing the 2030 Agenda at the national level, especially when it comes to identify the key targets to be implemented. However, none of the analysed voluntary national reviews presents a government effort to use multicriteria tools to aid the implementation the 2030 Agenda at the national level.

In fact, apart from the work presented by Khalifah *et al.* (2017), it was not found in literature any usage of multicriteria methods to deal direct with the SDGs. In addition, even though Weitz *et al.* (2017) described the application of a network analysis tool applied to the targets in the context of Sweden, they do not reveal the way they selected their treated targets. Bringing those pieces together, it is possible to conclude the high relevance of providing a multicriteria tool to the decision makers that would be able to rank the targets to have priority to be implemented in a country. It does not mean that the multicriteria methods would be enough. Instead, it means that the multicriteria methods could be combined with the developed cross-impact method to measure the interactions between targets (Nilsson *et al.* 2016b).

In order to identify the most suitable multicriteria to this finality, the next section investigates multicriteria methods related to Sustainable Development. The examples of multicriteria methods applied to the thematic will conduct to the identification of the most suitable multicriteria method to be used to rank targets associated to SDGs.

3.3. Challenges of analyzing the global targets' interactions

The policy assessments of interactions thus need to progress and become more complex. Decision makers need to turn their attention to the both design and implementation of policies focused on achieving the SDGs until 2030, thereby examining ways to institutionalize cross-sectoral strategies and strengthen mechanisms of governance. In addition, it thus creates a new momentum to further implement more efficient and integrated national strategies (Boas *et al*., 2016).

Nonetheless, the implementation is not an easy process; it is indeed very complex, especially when it comes to the definition and implementation of key sets of integrated targets (Griggs *et al.,* 2014). This shows the importance of strengthening the bridge between science and policy design. In the previous section (see section 3.2), three examples of works that embrace the policy-science interface were presented. Regarding the Indonesia case (Khalifah *et al*., 2017), it is important to emphasize one more time their smart choice of using the ANP approach which recognizes the interdependence between the treated elements. It reveals that the use of multicriteria methods to treat the SDGs should be explored.

The usages of multicriteria tools to treat Sustainable Development calls are not new at all. During the past few decades, they have showed themselves to be very useful in prioritizing and treating indicators related to the multiple sectors that integrate the Sustainable Development strivings. Kumara *et al.*(2017) performed an extensive review in various Multiple Criteria Decision Making (MCDM) techniques applied to the sphere of sustainable energy. This articles objective consists in applying various methods with focus on renewable energy planning and discusses their strengths and weaknesses. Among them are the following methods: TOPSIS by Hwang and Yoon in 1981, PROMETHEE by Brans and Vincke in 1985, and AHP by Saaty in 1970's. Even though it does not illustrate the Sustainable Development as a whole, it focuses only on Energy, which corresponds to only one of the thematic that integrates SDGs.

On the other hand, Boggia *et al.* (2010) developed a method to attribute weights of ranking areas to understand the needed specific technical and/or financial support to develop sustainable growth. The authors have applied the multi-criteria method taking into account the multi-dimensions of sustainability.

Another example that illustrates big attempts of using multicriteria to follow the Sustainable Development pathways is brought by (Jayaraman*et al.,* 2015; Jayaraman *et al.,* 2016). This proposal consists in a Weighted Goal Programming that integrates efficient allocation of energy resources to simultaneously achieve sustainability on GDP growth, electricity consumption and GHG emissions. The method assist decision makers in achieving the goals 7 (Energy) and 13 (Climate Change), which is emphasized by the author, but he doesn`t apply the method on the targets themselves.

Martins (2017) applied the fuzzy AHP-TOPSIS to rank renewable energy sources with the objective to identify the best option to be implemented in the Rio de Janeiro City. His adopted methodology considers the uncertainty and imprecision of specialists opinions, by adopting a fuzzy logic approach. His study

was based on the integration of two fuzzy multi-criteria methods of decision support - Fuzzy Analytical Hierarchy Process (FAHP) and Fuzzy Technique for Order of Preference by Similarity to Ideal Solution (FTOPSIS).

From all the analyzed methods, the fuzzy AHP-TOPSIS approach suits better to the objective of this section; it not only ranks alternatives by combining the strong points of two classic methods, but also it integrates a fuzzy approach to it. Since making decisions in general and the implementation of the 2030 Agenda are non-deterministic processes, the integration of a fuzzy approach to a multicriteria method will allow the coverage of the subjectivity of the targets analysis.

3.4. Final remarks on the chapter

The section 3.1 pointed that setting priorities is an important phase in the implementation of the 2030 Agenda at the national level (UNDG, 2015) (UNDG, 2017). Moving forward to the 3.2 section, (Khalifah*et al.,* 2017) brings the importance of using a multicriteria approach to setting priorities related to the SDGs. Still in the section 3.2, Weitz *et al*. (2017) shows that the seven-pointed typology (Nilsson *et al.,* 2016b) presented in the previous chapter (see section 2.2) is a useful tool in identifying the key targets in the context of a country. Both sections also presented the multiple efforts that have been made by both government and science to apply the 2030 Agenda to the National level. Moreover, it shows how science can go much more far in exploring the application of SDGs, which would be a huge assistance to policy makers.

The review presented through this chapter reveals the existence of a gap in the literature related to the application multicriteria methods to hierarchize targets associated to the SDGs. The section 3.3 conducted to the conclusion that the fuzzy AHP-TOPSIS method used by Martins (2017) can fill this gap, by carrying a review of multicriteria methods applied to Sustainable Development.

The fuzzy AHP-TOPSIS is the perfect tool to provide input data to the cross-impact matrix adopted by Weitz *et al.* (2017). These both methods can integrate a systemic conceptual model for identifying the key targets to be implemented in the context of a country. This model will be able to bring up the importance of considering the subjectivity of humans judgement. This overview allowed the conception of a model that will be presented the next chapter.

4
Systemic conceptual model to define the 2030 Agenda at the national level: integration of multicriteria methods, structural analysis, and network theory

As it was previously discussed, each SDG contains a group of targets that address directly to a specific thematic, and many others indirectly. When it comes to framing a strategy to reach those targets the question is: Once progress is made on them, which targets can be catalysts to others? The process of answering this question can't be based on opinions that are naturally tendentious and partial, it needs to be assertive and efficient. Therefore, the model to be presented in this chapter is divided in three phases: (i) defining criteria and attributing weights to them,(ii) ranking those targets in the light of the determined criteria, and then (iii) applying structural analysis on the ranked targets. The first two phases consider the uncertainty of non-deterministic processes by using a fuzzy linguistic approach.

As the previous chapter showed that no precise mathematical method was found in the literature to identify the targets related to the SDGs that should be prioritized in the implementation of 2030 Agenda in a country, this chapter, which is structured in 4 sections, has the ambition of filling this gap in literature. The section 4.1 presents the overview of the model, which consists of four phases that will be described in the sections 4.2., 4.3, 4.4 and 4.5. While the both sections 4.2 and 4.3 are dedicated to respectively presenting the fuzzy AHP and fuzzy-TOPSIS methods, the section 4.4 is deepened in the investigation of the direct and indirect influence of one target on another by applying a structural analysis model. Finally, the section 4.5 will describe network analysis method, which will provide the final visualization.

4.1.
General view of the conceptual model

From all those methods introduced in the section 3.3, the fuzzy logic combined to the hybrid method composed by the Analytical Hierarchical Process (AHP) and Technique for Order of Preference by Similarity to Ideal Solution (TOPSIS) was chosen to be part of this conceptual model. The fuzzy set logic

guarantees that the uncertainties and imprecision associated with the decision processes are considered, whereas the combination of the strong points of the AHP and TOPSIS methods can reduce the complexity of ranking alternatives.

The AHP was introduced and defined by Thomas Saaty in 1980 and it has been widely used during the past few decades as a decision-making tool for determining priorities among different criteria that will conduct the evaluation of a set of alternative options to identify the best decision to be made. However, instead of using the classic AHP method, this conceptual model is integrated by the fuzzy AHP method. It combines the AHP method with fuzzy set theory to solve fuzzy hierarchical problems (Taylan *et al.,* 2016, Yang *et al.*, 2015, Vinodh *et al*., 2014, Patil and Kant, 2014).

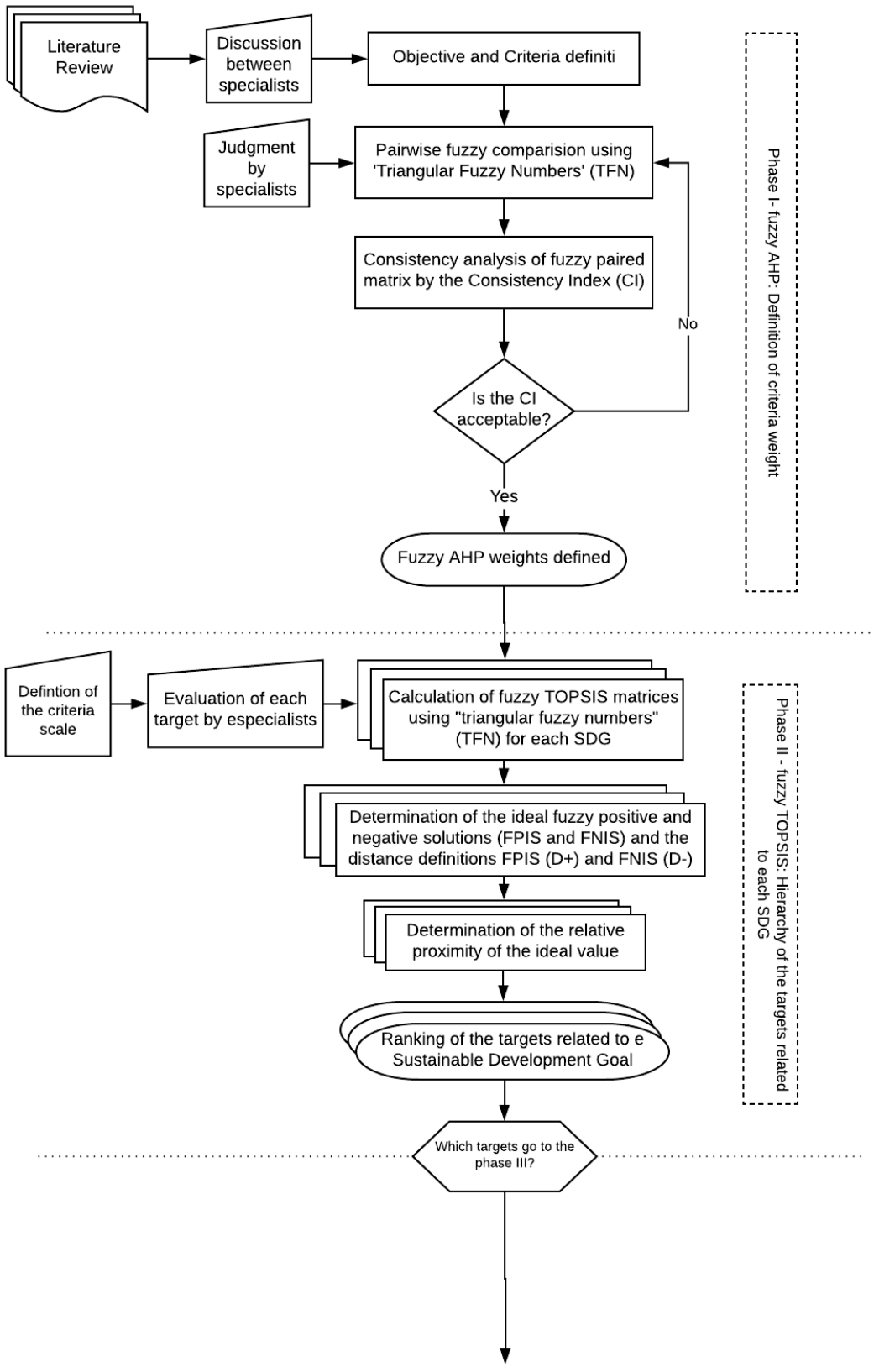
The fuzzy-AHP and fuzzy-TOPSIS methods were first integrated by Trindade in 2016 to monitor innovative capacities of enterprises. Both methods correspond respectively to the phase 1 and phase 2 of the systemic conceptual model to be presented in this section.

The fuzzy-AHP has the ability of simplifying the criteria weight attribution into a series of paired comparisons by capturing the subjective and objective aspects of the human decisions; and more, it can calculate the consistency of the results. However, when it comes to a large number of alternatives, thing alternatives gets complicated. On the other hand, the fuzzy-TOPSIS method can smartly rank alternatives by identifying the best solution, which is relatively close of the best solution and relative from the ideal negative solution. The fuzzy-TOPSIS method does not have a strong and consistent way of attributing weight to criteria, which can be provided by the fuzzy-AHP. Then, it is possible to conclude that both methods complement each other.

The TOPSIS method, developed by Hwang and Yoon (1981), is a technique recognized by allowing the identification of the solution that is the closest to the ideal positive solution (PIS) and the furthest away from the ideal negative solution (NIS). The ideal alternative is the one that has the shortest distance from the ideal positive solution and the longest distance from the ideal negative solution, based on the TOPSIS degree of optimization concept Cheng and Lin (2012). The fuzzy approach to the TOPSIS method brings the subjectivity and imprecision of the specialists judgements. Aiming to absorb the subjectivity and the imprecision of human judgments into the process of ranking alternatives, Şengül *et al*. (2014) combined the fuzzy logic with the TOPSIS method.This procedure needs to be done to each one of the sixteen SDGs. After that, the specialists should select the top targets among them and move to the next phase.

In the third phase, a structural analysis is applied to assess the direct and indirect interactions of the targets with respect to long term development of the 2030 Agenda. The prospective structural analysis started to be applied by the French scholars in the 1960`s, it aims to identify the key factors in the system dynamics; and also the ways that variables can influence each other. The first step of this phase is to select a cross-impact matrix which will consist in a web of direct interactions. The row and column sums must be analyzed; it is also possible to notice in this phase the ranking of targets. Then this matrix should be multiplied by itself. During this moment the specialists will notice that the row-sum and column-sum rankings will change, it happens because the indirect relation among variables come into evidence. This multiplication need to be carried on until the both rankings remain stable (second step). Then it will be possible to plot the graph dependence x influence to finally analyze which are the key targets to be implemented.

Figure 4.1 shows the general view of the systemic conceptual model to prioritize the global targets to be included in the 2030 Agenda, at the national level.



(cont. in the next page)

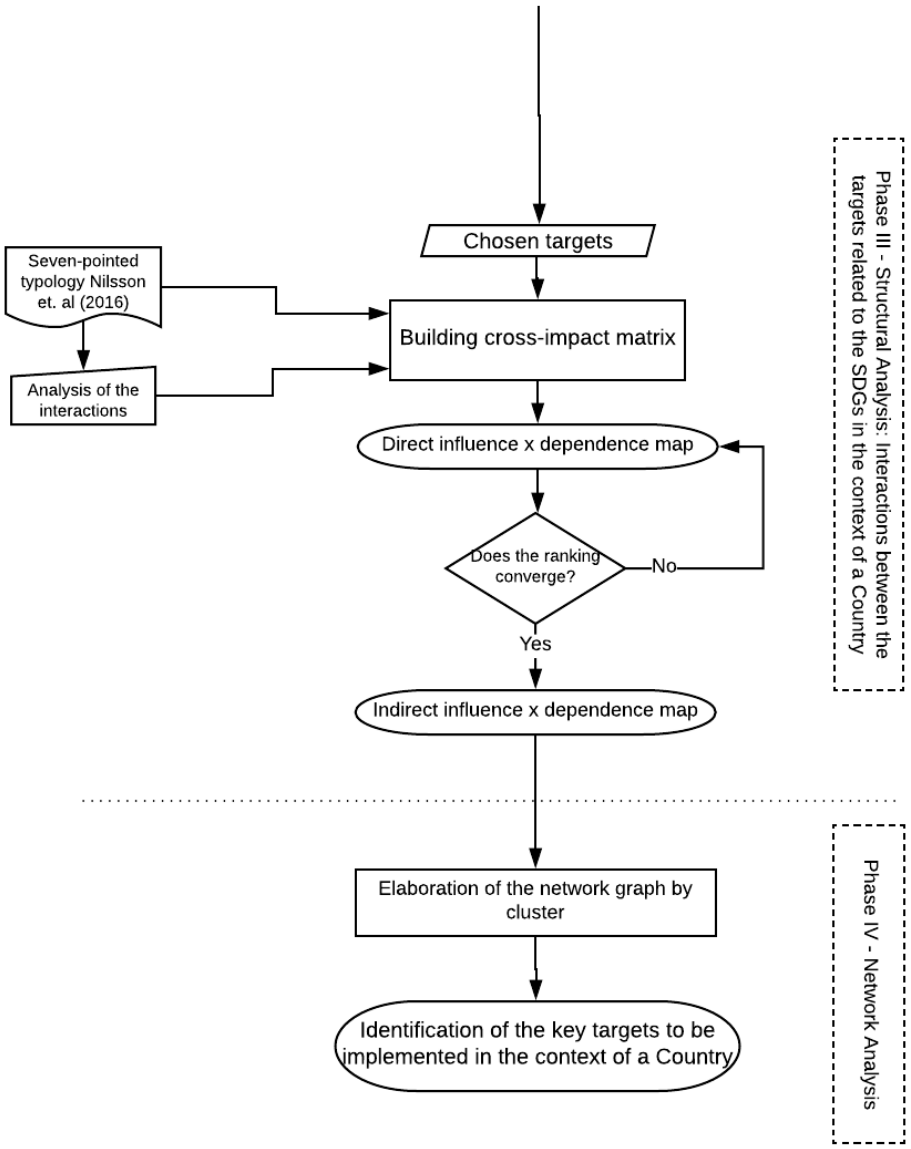


Figure 4.1 – General view of the systemic conceptual model to define the 2030 Agenda at the national level

Source: Own elaboration.

The following sections describe in detail each phase of the conceptual model.

4.2. Phase I: fuzzy-AHP for criteria weighting

This section embraces two from the three phases presented in the last section and intends to describe how fuzzy-AHP-TOPSIS can be applied to the

targets associated to the SDGs in the context of a country. Once fuzzy-AHP has provided the criteria weight, it is possible to run the fuzzy-TOPSIS needs to each SDG.

After analysing once more the literature to identify which criteria could best illuminate the targets evaluation. The internalization or “nationalization” of the 2030 Agenda is an ambitious process that faces limited resources and requires coordinated, coherent, and effective strategic plan of government (O’Connor *et* al., 2016).

It is important to recognize that for some countries or local contexts is not possible to internalize all targets due to critical issues of its socioeconomic and political contexts. In addition, the first point of reference to “nationalize” the global targets is the set of ongoing programs and plans (O’Connor *et* al., 2016). The identification of the policy coherence to the selected global targets facilitates the implementation of the 2030 Agenda at the national level.

Taking all of this into account, the specialists involved in the preliminary experiment presented in chapter five determined three criteria that should be used when this model is applied to select global targets in the context of a country:

- C1 - Relevance of the target facing the country challenges;
- C2 - Policy coherence for the target implementation;
- C3 - Criticality of the country indicators concerning the target.

It is worth to mention that during the development of the academic experiment focusing on the Brazilian 2030 Agenda, as reported in chapter 5, four criteria were thought for the selection of global targets with the support of the fuzzy method AHP-TOSPIS. However, the poor preliminary results of the experiment indicated that the fourth criterion – ‘resources’ availability for implementing the target’ – should not be considered in this phase, i.e. the prioritization of the global targets to be considered in the country’s Agenda. As a matter of fact, the fourth criterion 'resources’ availability for implementing the target’ should be employed only in the next phase, with a view to implementing the prioritized global targets themselves, It should be considered together with other well-known criteria adopted in program & project portfolio management.

When the three above mentioned criteria are combined, they convey a picture of a target adequacy in the context of a country. While the criterion C1 aims to identify how significant a target can be in achieving the key objectives of a country, the C2 and C3 criteria bring into evidence the alignment of the countries Agenda with the 2030 one.

The next step is constituted in assigning weights to the criteria, and this judgment is made by experts on the themes related to the 2030 Agenda. As said in the last section, these weights will be assigned through the Analytical Hierarchical Process (AHP) the evaluation by specialists will be not only based in their opinion, but it considers also the data provided by UN Dashboard. Then it was concluded that the relation between the UN Dashboard indicators and the targets is itself imprecise. Not all the indicators have been developed yet, as it was explained in the section 2.1. Then many of the indicators presented in the Dashboard are provisory ones that are already accessible.

The criteria weights are determined through three steps: (i) paired evaluation by specialists and decision makers, considering the subjectivity of the human judgment; (ii) creation of fuzzy matrices of paired comparisons using 'triangular fuzzy numbers' (TFN); (iii) the consistency check of the results of paired comparison matrices. All the equations related to those phases were taken from the dissertation of Martins (2017), and they can be accessed in the Annex 2 attached to this dissertation.

This first step considers the interdependences established between the different criteria and the weights are the result of a paired comparison; it is guided by the following two questions: Which one of the two criteria has preference on another? How much more important is this criterion in the comparison with the other? The first question guides the paired comparison of preference, while the second question orients the assignment of a value to the level of importance that one criterion has over the other; this will be measured through the nine-pointed (Table 4.1) typology proposed by Saaty (1980). After identifying which criterion has preference over the other, it must be evaluated the degree of this relative importance.

Table 4.1 – Pairwise comparison between criteria

Judgment of the relative degree of importance between the criteria										
To select the targets within each SDG		**Degree of relative importance**								
		1	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**
[ ]Relevance of the target facing the country challenges	[ ] Policy coherence for the target implementation									
[ ] Relevance of the target facing the country challenges	[ ] Criticality of the country indicators concerning the target -- UN Dashboard									
[ ]Policy coherence for the target implementation	[ ] Criticality of the country indicators concerning the target - UN Dashboard									

Source: Own elaboration.

As this conceptual model intends to consider the subjectivity, uncertainty and imprecision of the human opinions, a fuzzy linguistic approach analogue to the nine-pointed scale conceived by Saaty should be used (Table 4.2). This methodology decided not to consider the imprecision of the “same importance” judgment, however this point can still be discussed in future studies. All the other triangular fuzzy numbers vary from the lower value (corresponding to the previous Saaty’s value) to the upper value (corresponding to the next Saaty’s value). As the preference absolute is the highest possible value, its upper values is itself.

Table 4.2 - Linguistic terms and their respective fuzzy values

Level of importance according Saaty	Definition	Triangular fuzzy numbers
1	Same importance	(1,1,1)
2	Preference between the same and moderate	(1,2,3)
3	Moderate preference	(2,3,4)
4	Preference between moderate and strong	(3,4,5)
5	Strong preference	(4,5,6)
6	Preference between strong and very strong	(5,6,7)
7	Very strong preference	(6,7,8)
8	Preference between very strong and absolute	(7,8,9)
9	Absolute preference	(8,9,9)

Source: Own elaboration.

The calculation of the consistency ratio (equations and parameters can be accessed in the Annex 2) will determine if the first and second steps need to be reviewed and redone. Once the consistency is accepted, it is possible to calculate the weights assigned to the criteria (equations in the annex 2) and move forward to the Fuzzy-TOPSIS phase.

4.3
Phase II: fuzzy – TOPSIS for hierarchizing global targets associated to each SDG

This phase is conducted in six steps: (i) definition of the criteria scale (ii) judgement by specialists, considering the subjectivity of the non-deterministic judgment (iii) constitution of the decision matrices, using the set of fuzzy linguistic

terms; (iv) normalization of the matrixes; (v) determination of the ideal fuzzy positive and negative solution (FPIS and FNIS) and distance definition for FPIS (D+) and FNIS (D-); (vi) determination of the relative proximity of the ideal value, resulting in final ordering. All the equations related to these steps can be accessed in the Annex 2 attached to this dissertation.

The first of all steps consisted in defining a scale to the criteria from the fuzzy-AHP phase. The adopted scale to this model is presented in the table 4.3. The crisp scale is the one that the specialist will use, during the second step, to evaluate the alternatives in the light of the established criteria.

Table 4.3 - Defining the Crisp and Fuzzy scales to each criterion

Criteria	Attributes	Associated crisp scale	Associated fuzzy scale
C1 - Relevance of the target facing the country challenges	very high relevance	4	(3;4;4)
	high relevance	3	(2;3;4)
	medium relevance	2	(1;2;3)
	no/low relevance	1	(1;1;2)
C2 –Policy coherence for the target implementation	high alignment	3	(3;3;2)
	medium alignment	2	(3;2;1)
	no/low alignment	1	(1;1;2)
C3 - Criticality of the country indicators concerning the target - UN Dashboard	Red	4	(3;4;4)
	Orange	3	(2;3;4)
	Yellow	2	(1;2;3)
	Green	1	(1;1;2)

Source: Own elaboration.

Regarding the criterion C1, a target considered very high relevant when it reflects the country reality according to its geography, biomes, social factors, level of development and culture among other characteristics.

In sequence, the evaluation of the criterion C2 requires the content analyses of the government programs. A high alignment indicates that the government programs have a direct contribution to the target fulfilment.

Finally, the criterion C3 consists in the results delivered by the UN Dashboard indicators. Since not all of the indicators have been developed yet, as it was explained in the section 2.1, not all of targets were monitored and evaluated. Then, if a target still does not have an associated indicator, it should be evaluated according to the colour of the Goal under which the target is.

After the conduction of all evaluations, the results must be fuzzified according to the corresponding fuzzy scale and organized in a decision matrix (third step).Then the fuzzy decision matrix needs to be normalized. The forth step considers the independence of each criterion. As each one has its own nature, meaning and scale, it is not possible to compare one to another. Therefore, it is necessary to normalize the original matrix by means of a linear standardization.

After that, it is the fifth step; the moment to determine both the Fuzzy Positive Ideal Solution (FPIS) and the Fuzzy Negative Ideal Solution (FNIS); and then calculate the Euclidean distance, which sets the distance to FPIS (*D*+) and for FNIS (*D*-). Among the standard fuzzy values, the maximum values attributed to each FPIS criterion (*vj*+) and the minimum values assigned to each FNIS criterion (*vj*-) will be found. Then the matrix receives new denotations V + and V-, which will be calculated according to the distance to the FPIS (*vj*+), and the distance to the FNIS *(vj*-), respectively.

Finally, by taking the sixth step, it is possible to determine the coefficient of relative proximity (equations in Annex 2). Once it is calculated the coefficient to each alternative, it is possible to rank the coefficients and then obtain the final ranking of targets associated with one SDG. This procedure needs to be done to each one of the sixteen SDGs.

Before going further to next phase, the specialists need to analyse the ranking of alternatives to each ranking and decide which alternatives will be the input data to the next phase. This study recommends that, at least, the top two alternatives must be considered.

If more than two alternatives are tied on the first place, all of them should be considered to the next phase. If only one alternative occupies the first place and two or more alternatives tie in second, the first ranked alternative and all alternatives on the second place must be considered.

4.4. Phase III: structural analysis for identifying the key global targets at the national level

This section aims to go deeper in identifying the key global targets that must be prioritized and included in the 2030 Agenda at the national level. The first subsection consists of the construction of a structural analysis' matrix with the identification of the direct relations between the variables (Weitz *et al.,* 2017) with the application of the seven-pointed typology (Nilsson, *et al.,* 2016a) already

explained in the section 2.2.This stage will be described in the subsection 4.3.1. of this section.

The first step of this phase consists in listing all the variables of the system. According to Godet (1994), this is a very important step and it needs to embrace all intuitive methods and brainstorming, which consist in research; file organizations; and meetings among specialists and stakeholders with different points of view (political, social, economic, technological...). In fact, this step is analogue to the two previous phases that integrates this conceptual model. The fuzzy-AHP-TOPSIS is a method that is able to consider, in a structured way, all the brainstorming, opinions of stakeholders, contributions of specialist and inputs from literature. The absorption of all these information is structured in scales to be evaluated in the light of established and weighted criteria. And more, during this process, it is considered the subjectivity and bias of all opinions and point of views. As result, the method provides a ranked list of alternatives, which will be treated as variables in the structural analysis this phase.

Coming back to the context of targets: ideally, this third phase of the conceptual model should be applied to all 169 targets contained in 2030 Agenda. This meansthat169x 168 = 28392 interactions would be analysed. However, reaching this value requires a lot of resources such as work-time of specialists. Due to this, the first and second phases are essential to determine a start amount of targets to be structurally analysed.

This study suggests that the first round of analysis should be done with the top two ranked alternatives by the fuzzy-AHP-TOPSIS. Afterwards, in other times, if the specialists decide to apply the third phase of this model to another set of targets, it is recommended that the new aggregated targets are added in the previous matrix and also crossed with the previous treated targets as well. Once this final list of targets is decided, it is possible to map the direct influences and dependences among the targets as described in subsection 4.4.1.

4.4.1. Investigating the direct interactions between global targets

This second step of the structural analysis consists in the identification of the direct relationships of influence and dependence between targets. This step is analogue to the work conducted by Weitz *et al.* (2017) found during the literature review and presented already in the section 3.2 of this dissertation. The cross-impact matrix to be generated is a square matrix, where it can be analysed the way that each selected target directly interacts with all the others. The interactions in

the diagonal are obviously not considered, since a target cannot directly interact with itself.

The dynamics of interactions between targets can be analysed by using a binary example to a system that is identified by three variables: A, B and C. The figure 4.2 presents the direct relation of influence and dependence. A and B influence each other, which also means that one depends on the other. B influences C, but C does not influence B. While C depends on B, C also influences A. In turn, A does not directly influence C.

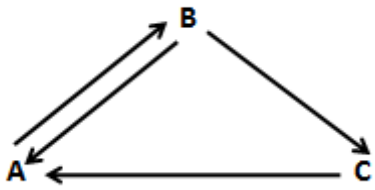


Figure 4.2 - Example of how can three variables interact in a system.
Source: Adapted from Godet (1994, p. 94).

These interactions are disposed in binary terms in the table 4.4., where 1 means that an element of the column exerts influence on one element of the row; and 0 means that the element of the column does not exerts influence on the element of the row. The number 1 that is the position a_{11} means that Target A exerts influence on Target B; and the number 1 in thea_{21} position means that B exerts influence on the A. Since a variable does not exert directly influence on itself, all the diagonal elements are 0. The sum in row means the global influence of each variable, whereas the sum on the column means the global dependence of each variable.

Table 4.4 - Cross-impact matrix M

M	**Target A**	**Target B**	**Target C**	
Target A	0	A→B	0	1
Target B	B→A	0	B→C	2
Target C	C→A	0	0	1
	2	1	1	

M	**Target A**	**Target B**	**Target C**	
Target A	0	1	0	1
Target B	1	0	1	2
Target C	1	0	0	1
	2	1	1	

Source: Adapted from Godet (1994).

The objective of the systemic conceptual model presented by this study goes beyond of analysing if interactions exist or not. It analyses the nature of this influence: negative and how negative, positive and how positive, or neutral. The objective of applying such methodology on targets is to understand and analyse

what occurs to the system when progress is made in one of its targets (variables). It is important to highlight that making progress does not mean to fully achieving it, it means to be any closer to the achievement.

Each target of the row needs to be crossed to all the other targets on the columns according to this following question that guides this analysis: *If progress is made on target i (rows), how this influences progress on target j (columns)*? The answers should be delivered according to the seven-pointed typology from Nilsson et al. (2016) presented already in the table 2.1 in the chapter 2.

Afterwards, it will be possible to verify if there are more positive or negative influences in the system, which means if making progress in one specific area is going to make easier for other targets to be achieved or not. In addition, it is possible to calculate the row-sum and the column-sum. While the row-sum indicates the general influence exerted from a target on all others, the column-sum shows how much dependent each target is on all the other targets.

The result of this tool application is a fundamental aid to the implementation process of the 2030 Agenda because it facilitates the elaboration of joint-polices and joint-actions. It orients a policy-maker to understand the consequences of their actions. A high row-sum suggests, for example, that once progress is made on this target, a large positive influence will happen on most of the others; in other words, it suggests that this progress makes the realization of other targets easier. The targets with a high row-sum can be recognized as key targets to be implemented in the context of a country. This hints the smartness of prioritizing those targets in the Government Agenda. Moreover, all the signalisations of negative consequences can help the decision-makers to consider means of mitigating the possible negative impacts.

The low or negative row-sum suggests that progress on that target might make the achievement of the other targets more difficult. It is important to highlight that both low and negative values in the both row-sum and column-sum do not evidence the roots of this value generation. In order to evaluate if that influence consists of a large number of negative influences on many targets or a few strong ones, it is necessary to analyse all the interactions presented on the row.

However, these values are not enough to identify the key targets. On this way it is necessary to go deeper into the identification and analysis of the indirect interactions. The analysis of the web of interactions (the phase IV) will bring the key variables into evidence.

4.4.2.
Investigating the indirect interactions between global targets

According to Godet (1994) the direct classification express the relationships that happen in a short or medium time horizon, whereas the indirect classification integrates the chain reactions. This sequence of impacts would necessarily take a longer time horizon such as 10-15 years, which matches with the 2030 Agenda.

Table 4.5 shows the first step of the investigation of the indirect relationships. The diagonal of the matrix represents the direct relations of each variable with itself, which does not exist. In this binary example all diagonal elements are 0, however when the M is squared these values in the diagonal may change. For example, the element in the position a_{11} in the matrix M^2 indicates that the target A influences indirectly itself. This indirect influence is integrated because when M was squared, the element a_{11} has absorbed all the interactions (influences and being influenced) that the target A had with all the other targets. Then the Target A indirectly influence itself.

Table 4.5 - Starting the investigation of indirect interactions

M	**Target A**	**Target B**	**Target C**	
Target A	0	1	0	1
Target B	1	0	1	2
Target C	1	0	0	1
	2	1	1	

M²	**Target A**	**Target B**	**Target C**	
Target A	1	0	1	2
Target B	1	1	0	2
Target C	O	1	0	1
	2	2	1	

Source: Adapted from Godet (1994).

Table 4.6 shows that the Target A influences itself through the influence that the Target A exerts on the Target B, which, in turn, has influence on A. In addition, it shows that even though B has a direct influence on A, it has also an indirect influence through the impact it exerts on the target C.

It is also important to highlight that when observing only the direct interactions, the Target B had the biggest row-sum, which means the most influent.; and the Target A was the most dependent (influenced), since it had the biggest column sum. Already in the first analysis of indirect impact (M x M=M^2), it is observed that the row-sum and column-sum ranking changes. It happens

because the elements got stronger when receiving impacts from indirect interactions.

Table 4.6 - Revealing indirect influences

M	Target A	Target B	Target C		M^2	Target A	Target B	Target C	
Target A	0	A→B	0	1	**Target A**	A→B→A	0	A→B→C	2
Target B	B→A	0	B→C	2	**Target B**	B→C→A	B→A→B	0	2
Target C	C→A	0	0	1	**Target C**	O	C→A→B	0	1
	2	1	1			2	2	1	

Source: Adapted from Godet (1994).

While the table 4.7 reveals that some Targets can indirectly influence themselves in a path of length 2, the table 4.7 reveals the indirect influence in a path of length 3.

Table 4.7 - Indirect influences in a path of length 3

M^3	Target A	Target B	Target C		M^3	Target A	Target B	Target C	
Target A	1	1	0	2	**Target A**	A→B→C→A	A→B→A→B	0	2
Target B	1	1	1	3	**Target B**	B→A→B→A	B→C→A→B	B→A→B→C	3
Target C	1	0	1	2	**Target C**	C→A→B→A	0	C→A→B→C	2
	3	2	2			3	2	2	

Source: Adapted from Godet (1994).

It is possible to observe now that the column-sum ranking remained stable whereas the row-sum ranking changed again. If we keep levering the power of the matrix, the both row-sum and column-sum rankings will remain stable as the table 4.8 shows. The row and column classification becomes stable when the elements are raised to a certain power, because when the matrix is multiplied by itself all the tendencies that are incorporated in each element get stronger. By levering the power, the whole system evolves towards organizing itself. The element in the position *a*21 in the M^4 has the first number 2 in this example, this means that when

the matrix M^3 was multiplied by the matrix M, two interactions in the path of length 4 were detected: B→C→A→B→A and B→A→B→C→A.

When the power was levered once more (Matrix M^4) the row-sum remained stable, but the column-sum changed. However when the power was levered again (Matrix M^5) both row-sum and column-sum remained stable, which indicates that the system is finally stable. Levering the power once more (Matrix M^6) there was again no change in the ranking, instead of that the differences between the sum got bigger, which gives more strength to each position. Then it is possible to conclude that the row and the column become stable at the forth order of interaction.

Table 4.8 - Achieving the row and column stability

M^4	Target A	Target B	Target C		M^5	Target A	Target B	Target C		M^6	Target A	Target B	Target C	
Target A	1	1	1	3	Target A	2	1	1	4	Target A	2	2	1	5
Target B	2	1	1	4	Target B	2	2	1	5	Target B	3	2	2	7
Target C	1	1	0	2	Target C	1	1	1	3	Target C	2	1	1	4
	4	3	2			5	4	3			7	5	4	

Source: Adapted from Godet (1994).

After that, it will be possible to observe that the global indirect influence of some targets can be increased through the chain reactions, which consists in the indirect propagation of the targets influence in the web of interrelations.

The next subsection will present the influence *versus* dependence charts, which will allow the identification of the variables clusters.

4.4.3. Identifying the determinant, relay and resultant global targets

The influence v*ersus* dependence map provides an overview of how the targets interact simultaneously with each other. According to Godet (1994) the variables can be grouped and classified in 5 different sectors(clusters): determinant variables (high influence and low dependence) variables; relay variables (high influence and low dependence); resultant variables (low influence and high dependence); autonomous (low influence and low dependence) variables; middle cluster (averagely influence and/or dependence) variables. This can be observed in the figure 4.3, M represents the medium point. The medium

point represents the average of the sum of the highest value and the lowest value, to both the influence and dependence axes.

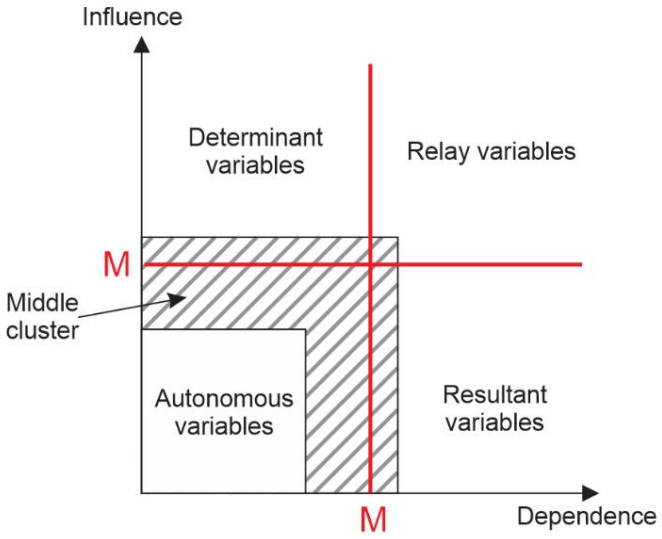


Figure 4.3 - Map of the interactions between variables
Source: Godet (1994.p. 99).

The variables (global targets) should be plotted according to their global column-sum and row-sum values. Then, it will be possible to identify their dynamics in the system. At least, two graphs should be plotted: to the matrix of direct interactions and to the resulting matrix.

The determinant variables are the high influential ones; they work as driving forces to the rest of the system. They can control the system as whole, giving to it inertia or movement to the rest of the system (Zali, et al., 2015).The targets that occupy these positions are the key targets, they need to be the first ones to be implemented. Making progress on these will bring the progress to many others. It does not mean that they won`t have any negative impact, but the fact that a target needed to have a high row-sum to occupy this position means that its impact is more positive than negative.

The relay variants are unstable by nature because any action on these variables will have repercussions on other variables (Godet, 1994), which could mean a great progress or a boomerang effect on the system as a whole. They can either amplify or forestall any initial impulse in the system (Zali *et al*., 2015). The resultant variables are the most influenced (dependent) ones, they are extremely unstable and susceptible. It worth to invest on making progress on these targets,

but the progress on them will only be guaranteed if the targets that exert influence on them are making progress and are not delivering negative impacts.

The autonomous variables are not significantly integrated in the chain reactions and they are not determinant to the future of the system; due to this they are sometimes addressed as excluded ones. These variables have a weak relation with the system, being relatively unconnected to it. It does not mean by any chance that these targets don`t need to be implemented; each one of the 169 has its importance and relevance. Being excluded means that its progress won`t propagated in web on interactions between the selected targets.

As the label already suggests, the resultant variables are impacted by the results of system. The progress on these targets will automatically occur when the system makes a progress as a whole.

Finally, the variables located in the middle cluster are the most difficult to analyze. Zali *et al.* (2015) address them as regulating variables. The specialists involved in the preliminary experiment, reported in chapter 5, believe that the progress of the implementation of the targets plotted in the middle cluster need to be done carefully, while observing the impacts of them in the entire causal chain.

4.5. Phase IV: network analysis for visualization of indirect interactions of global targets at the national level

This phase allows the visualization and analysis of the cross-impact analysis' results obtained in the third phase. It better communicates the complexity of the web of interactions by showing the link between targets. Then, it is possible to identify the strength and direction (if they come to or from the element) of those connections.

The analysis of a network reveals diverse information about its elements and interactions; some tools have been developed over the last few decades in order to improve the analysis of processes in a network (Borba, 2013).There are several software that allow not only a spatial visualization of the network structure but they also make several types of analysis.

From these tools the most important for this phase of the conceptual model are the global parameters which consist of degree distribution, path length, network centrality (Borba, 2013). The centrality is the statistical measure of the intensity of the connections of a given cluster, it can be calculated by the average value of the connections that exist between the targets.

Whilst the centrality measures the coherence of a topic, the density is the statistical measure of the strength of the links that associate the targets of a given cluster. This can be calculated by the sum of the squares of the coefficient of equivalence that bonds the clusters. It is the density that characterizes the protagonism of a target. The density can also show the relative position (the importance) of each cluster in the global map of interactions between the targets.

The matrices obtained in the last section can be represented by a graph where its elements are represented by vertices or nodes and their connections by edges. From the network perspective, each target is a node and the edges represent the connections between the targets.

Once the web of interrelations is generated by a software of network analysis, it should be possible to notice the intrinsic tendency of the elements to group together in clusters. In addition, the parameters of centrality and density of the links will be in evidence. The more impacting the targets are, the bigger the nodes.

4.6. Final remarks on the chapter

The presented systemic conceptual model in this chapter filled the literature gap related to the necessity of existing a pragmatic methodology to aid decision makers with the implementation of the 2030 Agenda at the national level.

It combined different mathematical mechanisms presented in the literature, providing to each one of them perspectives of innovation. To the fuzzy approach to the hybrid AHP-TOPSIS method, it is proposed an after phase to analyze how the alternatives can benefit or counteract themselves. To both the study carried by Weitz *et al.* (2017) and to the French scholars, who developed the Structural Analysis methodology, it was provided an early phase of setting the variables that are going to feed the crossed-impact system. The fuzz-AHP-TOPSIS suits perfectly as an early phase to the structural analysis because it considers the subjectivity and uncertainty of the specialists' opinions, and organize all of them in a pragmatic and consistent methodology. Still to Weitz *et al.* (2017),it is proposed a further systemic analysis of evidencing the indirect relations between the variables through theirs chain reactions; and then the identification of the key targets to be prioritized in the 2030 Agenda implementation at the national level.

5
Application of the model to define the Brazilian Agenda 2030: a preliminary experiment

This chapter has the purpose of describing and discussing the results of a preliminary experiment that was developed along with the elaboration of conceptual model that integrates multicriteria methods, structural analysis and networks theory. This experiment was developed within the boundaries of the Post-graduation Program in Metrology of PUC-Rio, with the strict objective of verifying if the quantitative tools could be effectively integrated to the model in a consistent way (or not). The specialists who conducted this experiment agreed on the exclusion of the 17th Goal and all the other targets related to the means of implementation. This means that a total of 62 targets was not considered.

Only the thematic targets were contemplated, which corresponds to a total of 107 targets. and with the intention of is not focused on the final results, instead of that, it intends to verify if the mathematical model is consistent. The specialists, who conducted this research, agreed on not including the 17th Goal and all the other targets related to the means of implementation in this experiment; this means that a total of 62 targets was not considered. Only the thematic targets were contemplated, which corresponds to a total of 107 targets. Since the focus of this research is methodological, the specialists who opined were the same who developed this conceptual model. This empirical study intends to analyze the coherence of the results.

The sections 5.1 and 5.2 respectively correspond to the validation of the phases I and II of the proposed conceptual model. The objective was to provide a final list of targets, which is going to be the input data to the third phase. Once this list with selected targets was obtained, it was possible to move to the structural analysis phase. In this third phase of the proposed conceptual model, it was revealed the causal chain of influence and dependence between the targets associated with the SDGs in the Brazilian context (see section 5.3).

Finally, the section 5.4 shows the graphs resulted from the network analysis. It was possible to visualize which targets determine the dynamics of the whole system (the Brazilian 2030 Agenda). These graphs can guide decision makers in

setting priorities during the implementation process of the 2030 Agenda at the national level.

5.1.
Phase I: fuzzy-AHP for criteria weighting

First of all, it was necessary to assign weights to the established criteria as previously explained in the section 4.2. Table 5.1 shows the results of the paired comparison judgment. The found consistent ratio was of 0,004, which is lower than 0,1, then this value is consistent; on this way it is possible to generate the matrix of pairwise comparison.

Table 5.1 – Pairwise comparison between criteria in the Brazilian context

Judgment of the relative degree of importance between the criteria									
To select the targets within each SDG		**Degree of relative importance**							
		1	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**
[x] Relevance of the target facing Brazilian challenges	[ ] Policy coherence for the target implementation		x							
[x]Relevance of target facing Brazilian challenges	[ ] Criticality of the country indicators concerning the target - UN Dashboard			x						
[x]Relevance of target facing Brazilian challenges	[ ] Resource availability for the target implementation	x								
[x] Policy coherence for the target implementation	[ ] Criticality of the country indicators concerning the target - UN Dashboard		x							
[ ] Policy coherence for the target implementation	[x] Resource availability for the target implementation		x							
[Criticality of the country indicators concerning the target - UN Dashboard	[x] Resource availability for the target implementation			x						

Source: Own elaboration.

This result allowed the generation of a corresponding fuzzy matrix, which can be seen in the table 5.2; the final results are exposed in the table 5.3. The weights assigned to the criteria are the final obtained results of the fuzzy-AHP phase. They

will be used in the fuzzy-TOPSIS phase to hierarchize the alternatives (Targets associated with the Brazilian SDGs).

Table 5.2 - Matrix of paired comparison to weight the criteria

Matrix of pairwise comparison				
	C1	**C2**	**C3**	**C4**
C1	(1,1,1)	(1,2,3)	(2,3,4)	(1,1,1)
C2	(1/3,1/2,1/1)	(1,1,1)	(1,2,3)	(1/3,1/2,1/1)
C3	(1/4,1/3,1/2)	(1/3,1/2,1/1)	(1,1,1)	(1/4,1/3,1/2)
C4	(1,1,1)	(1,2,3)	(2,3,4)	(1,1,1)

Source: Own elaboration.

Table 5.3 - Fuzzy-AHP final results

Weights assigned to the criteria			
	L	**m**	**u**
C1	0,189	0,378	0,699
C2	0,072	0,165	0,440
C3	0,041	0,079	0,192
C4	0,189	0,378	0,699

Source: Own elaboration.

The criteria C1 (‘relevance of target facing Brazilian challenges’) and C4 (Resource availability for the target implementation) were assigned with the highest weights. This result agrees with the first accordance of the specialists that it is not possible to implement any actions (however relevant the target is) without proper financial and human resources. However, one of the conclusions delivered by this experiment is that all the issues related to implementation need to be carried one in posterior moment.

The second best weighted criterion was the C2 (‘policy coherence for the target implementation’), which reveals that the existence of ongoing programs and established polices facilitate the targets achievement. At last, the C4 (Criticality of the country indicators concerning the target - UN Dashboard) received the lowest weight. It suits to the fact that the Dashboard still does not expose with accuracy the currently stage of Brazil; as explained in the section 2.1 many indicators are still under development. However, it is important to highlight that even though with its low weight, the C3 criterion can still significantly influence the results.

5.2
Phase II: fuzzy – TOPSIS for hierarchizing global targets related to each SDG in the Brazilian context

Once the weights were obtained, it was possible to move to the fuzzy-TOPSIS phase. Even though all the results can be accessed in the Appendix 1, the results related to the SDG 1 and SDG 2 will be presented in this section as a matter of illustration.

The initial scale elaborated during the development of the model (Table 5.4) was used in this preliminary experiment. It was possible to verify some differences between this one and the one presented in the chapter 4 (Table 4.3). After the development of this experiment, the specialists concluded that it is really difficult to have no relevant or low relevant targets in the context of a country; and also, some targets can be very high relevant.

Concerning the criterion C2, it was noticed that low coherence of some government programs do not have a significant contribution to the target implementation, and then low coherence or even no coherence were aggregated in the same scale level. Regarding the criterion C3, there was a slight change in the four – point scale. It was adopted the range 1-4 instead of 0-3. Since the fuzzy-TOPSIS works with distances between values, the difference of ranges do not affect the results. However, the specialists agreed that the number 0 brings the idea of void or absence.

Table 5.4 - Defining the Crisp and Fuzzy scales to each criterion

Criteria	Attribute	Associated crisp scale	Associated fuzzy scale
Relevance of the target facing the Brazilian challenges	High relevance	3	(3;3;2)
	Medium relevance	2	(3;2;1)
	Low relevance	1	(0;1;2)
	No relevance	0	(0;0;1)
Policy coherence for the target implementation	High coherence	3	(3;3;2)
	Medium coherence	2	(3;2;1)
	Low coherence	1	(0;1;2)
	No coherence	0	(0,;0;1)
Criticality of the country indicators concerning the target -UN Dashboard	Red	3	(3;3;2)
	Orange	2	(3;2;1)
	Yellow	1	(0;1;2)
	Green	0	(0;0;1)
Resource availability for the target implementation	High availability	3	(3;3;2)
	Medium availability	2	(3;2;1)
	Low availability	1	(0;1;2)
	No availability	0	(0;0;1)

Moreover, in order to better demonstrate the effects of the fuzzy approach, the values related to the crisp TOPSIS were especially calculated only to the SGDs 1 and 2.Table 5.5 exposes the values that were assigned to the attributes for each target related to the SDG 1, whereas table 5.6 contains the results related to the SDG 2.

Only one specialist has evaluated these targets in the light of the established criteria with the objective to test the quantitative tools before developing a real empirical study involving multistakeholders – policy makers; academicians; representatives of private sector, and also members of non-governmental organizations.

Table 5.5 - SDG 1 crisp decision matrix

SDG 1	**Alternative targets**	**Criteria**			
		C1	**C2**	**C3**	**C4**
1.1	1.1 By 2030, eradicate extreme poverty for all people everywhere, currently measured as people living on less than $1.25 a day	3	3	2	2
1.2	1.2 By 2030, reduce at least by half the proportion of men, women and children of all ages living in poverty in all its dimensions according to national definitions	3	3	1	1
1.3	1.3 Implement nationally appropriate social protection systems and measures for all, including floors, and by 2030 achieve substantial coverage of the poor and the vulnerable	3	2	2	1
1.4	1.4 By 2030, ensure that all men and women, in particular the poor and the vulnerable, have equal rights to economic resources, as well as access to basic services, ownership and control over land and other forms of property, inheritance, natural resources, appropriate new technology and financial services, including microfinance	2	2	2	1
1.5	1.5 By 2030, build the resilience of the poor and those in vulnerable situations and reduce their exposure and vulnerability to climate-related extreme events and other economic, social and environmental shocks and disasters	1	1	2	1

Source: Own elaboration.

Table 5.6 - SDG 2 crisp decision matrix

SDG 2	Alternative Targets	Criteria			
		C1	C2	C3	C4
2.1	2.1 By 2030, end hunger and ensure access by all people, in particular the poor and people in vulnerable situations, including infants, to safe, nutritious and sufficient food all year round	3	2	2	1
2.2	2.2 By 2030, end all forms of malnutrition, including achieving, by 2025, the internationally agreed targets on stunting and wasting in children under 5 years of age, and address the nutritional needs of adolescent girls, pregnant and lactating women and older persons	2	2	0	2
2.3	2.3 By 2030, double the agricultural productivity and incomes of small-scale food producers, in particular women, indigenous peoples, family farmers, pastoralists and fishers, including through secure and equal access to land, other productive resources and inputs, knowledge, financial services, markets and opportunities for value addition and non-farm employment	1	2	2	2
2.4	2.4 By 2030, ensure sustainable food production systems and implement resilient agricultural practices that increase productivity and production, that help maintain ecosystems, that strengthen capacity for adaptation to climate change, extreme weather, drought, flooding and other disasters and that progressively improve land and soil quality	3	1	2	3
2.5	2.5 By 2020, maintain the genetic diversity of seeds, cultivated plants and farmed and domesticated animals and their related wild species, including through soundly managed and diversified seed and plant banks at the national, regional and international levels, and promote access to and fair and equitable sharing of benefits arising from the utilization of genetic resources and associated traditional knowledge, as internationally agreed	2	0	2	2

Source: Own elaboration.

All the assigned crisp values were converted according to the fuzzy-TOPSIS scale (table 5.4). After that, it was possible to generate the fuzzy decision matrix of each SGD as it is illustrated, respectively to the SDGs 1 and 2, in tables 5.6 and 5.7.

Table 5.7 - SDG 1 - Fuzzy decision matrix

SDG 1	Fuzzy decision matrix														
	1.1			1.2			1.3			1.4			1.5		
	L	m	U	l	m	U	L	m	u	l	M	u	L	m	U
C1	2	3	3	2	3	3	2	3	3	1	2	3	0	1	2
C2	2	3	3	2	3	3	1	2	3	1	2	3	0	1	2
C3	1	2	3	0	1	2	1	2	3	1	2	3	1	2	3
C4	1	2	3	0	1	2	0	1	2	0	1	2	0	1	2

Source: Own elaboration

Table 5.8 - SDG 2 - Fuzzy decision matrix

SDG 2	Fuzzy decision matrix														
	2.1			2.2			2.3			2.4			2.5		
	l	m	U	l	m	u	l	m	u	l	M	u	L	m	U
C1	2	3	3	1	2	3	0	1	2	2	3	3	1	2	3
C2	1	2	3	1	2	3	1	2	3	0	1	2	0	0	1
C3	1	2	3	0	0	1	1	2	3	1	2	3	1	2	3
C4	0	1	2	1	2	3	1	2	3	2	3	3	1	2	3

Source: Own elaboration

After that, it is possible to calculate the distances FPIS and FNIS as presented in tables 5.9 (SDG 1) and 5.10 (SDG 2). All the calculated coefficients are the final values and they are finally ranked in a decreasing order. The crisp ranking was calculated as proposed originally by Saaty (1980). The crisp order is the one that the specialists first expected when they take a look on the Crisp decision matrix. Nevertheless, when it is considered the subjectivity, imprecision and uncertainty of the human judgment through the Fuzzy linguistic approach, the result is not anymore s obvious. As it is presented in both tables, the fuzzy and crisp rankings are slightly different. This happens due to the consideration of the subjectivity and imprecision of the human judgment. When the uncertainty is incorporated in a Multicriteria method through the use of the fuzzy linguistic approach, some alternatives get stronger. It is interesting to note that in most of the cases the first alternative remains the same to both, especially when this one is by far the best. The fuzzy influence can be more easily noticed when it comes to positions with a shorter distance between the alternatives.

In table 5.9, the first and the last positions are the same to the crisp and fuzzy cases. On the other hand, the in-between three alternatives were reorganized. It happened because the alternative 1.1 was by far the best, whereas the alternative 1.5 was by far the worst. When it comes to the SDG 2 (table 5.10), the alternatives 2.4 and 2.1 were by far the best two alternatives. Due to this, they remained

occupying the same positions in both rankings. However, in the case of the alternatives 2.2, 2.3 and 2.5, which got such close scores, the order was altered.

Table 5.9 - SDG 1 – Fuzzy-TOPSIS results; fuzzy and crisp rankings

SDG 1	FPIS	FNIS		Final Ranking	
	D+	D-	CCi	Fuzzy	Crisp
1.1	2,493	2,500	0,501	1.1	1.1
1.2	2,728	2,076	0,456	1.3	1.2
1.3	2,690	2,259	0,442	1.4	1.3
1.4	2,790	2,211	0,432	1.2	1.4
1.5	3,013	1,789	0,373	1.5	1.5

Table 5.10 - SDG 2 – Fuzzy-TOPSIS results; fuzzy and crisp rankings

SDG 2	FPIS	FNIS		Final Ranking	
	D+	D-	CCi	Fuzzy	Crisp
2.1	2,690	2,259	0,456	2.4	2.4
2.2	2,883	2,020	0,412	2.1	2.1
2.3	2,790	2,211	0,442	2.3	2.2
2.4	2,556	2,321	0,476	2.5	2.3
2.5	2,867	2,024	0,414	2.2	2.5

After applying the fuzzy-TOPSIS to all of the sixteen SDGs, it was possible to conclude that the top alternatives of each SGD met the expectations of the specialists. In the case of the SDG 1, the target 1.1 (eradicate extreme poverty*)* was by far, in both crisp and fuzzy-TOPSIS, the highest priority to Brazil. This perfectly portraits the Brazilian context of social inequality, that is the roots of many problems inherent of the country such as high violence index. In the first analysis, using the crisp TOPSIS, the Alternative 2(1.2 - halve the proportion of people living in poverty) was considered the second highest priority. However, after considering the subjectivity of the human judgment, the Alternative 3 raised to the top two podium, showing that the target 1.3 (social protection, including floors)must has a significant role in the Brazilian Sustainable Development pathway. The results became even more satisfactory, when the fuzzy linguistic approach “replaced” the alternative 2 (target 1.2) by the alternative 3 (target 1.3). This conclusion is based on the fact that the target 1.2 is quite analogue to the target 1.1.

Regarding the SDG 2, the fuzzy logic reinforced the crisp judgment. The fact that the targets 2.4 (sustainable food production)and 2.1 (end hunger) have occupied the top two position perfectly reflects big challenges of the Brazilian context that have a turning point significance. Cultured products in general have a significant role in the Brazilian economy. Due to this, large national areas are

intended to such purposes; generating huge environmental impacts such as pollution (high use of pesticides) and deforestation. If the country manages to eradicate the hunger and to export cultured products (preserving the economic stability) with a sustainable and resilient agriculture, a huge step will be given towards the 2030 Agenda Goals achievement.

After taking those analyses in consideration, the specialists, who conducted this study, concluded that the adopted method was able to deliver very satisfactory and coherent results. Therefore, this method can be indeed acknowledged as a powerful tool to assist the decision makers in setting priorities in the process of implementing the 2030 Agenda.

The next section is going to present the results regarding the third phase of the systemic conceptual model developed by this study. This promises to map the interconnections of the Targets system that, as explained in the chapter two, needs to be interpreted as a whole. The section 5.3 aims to investigate the web of the direct impacts between the targets as well as the propagation of their indirect relations, regarding naturally the Brazilian context.

5.3. Phase III: structural analysis for identifying key global targets in the Brazilian context

As previously explained, this methodology considered the top two positions of the final rankings of each SDG. Specifically regarding the SDG 7, two targets drew on the second position, then, as part of this method, both of them were considered. In the end, thirty-three targets under the SDG 7 were considered to be treated, whereas only two targets under each another SDG were considered.

Table 5.11 presents the 33 targets selected by the fuzzy-AHP-TOPSIS method, with their receptivity official descriptions.

Table 5.11 - The 33 targets selected for Brazil

1.1	By 2030, eradicate extreme poverty for all people everywhere, currently measured as people living on less than $1.25 a day.
1.3	Implement nationally appropriate social protection systems and measures for all, including floors, and by 2030 achieve substantial coverage of the poor and the vulnerable.
2.1	By 2030, end hunger and ensure access by all people, in particular the poor and people in vulnerable situations, including infants, to safe, nutritious and sufficient food all year round.
2.4	By 2030, ensure sustainable food production systems and implement resilient agricultural practices that increase productivity and production, that help maintain ecosystems, that strengthen capacity for adaptation to climate change, extreme weather, drought, flooding and other disasters and that progressively improve land and soil quality.
3.3	By 2030, end the epidemics of AIDS, tuberculosis, malaria and neglected tropical diseases and combat hepatitis, water-borne diseases and other communicable diseases.
3.8	Achieve universal health coverage, including financial risk protection, access to quality essential health-care services and access to safe, effective, quality and affordable essential medicines and vaccines for all.
4.1	By 2030, ensure that all girls and boys complete free, equitable and quality primary and secondary education leading to relevant and effective learning outcomes.
4.2	By 2030, ensure that all girls and boys have access to quality early childhood development, care and pre-primary education so that they are ready for primary education.
5.2	Eliminate all forms of violence against all women and girls in the public and private spheres, including trafficking and sexual and other types of exploitation.
5.5	Ensure women's full and effective participation and equal opportunities for leadership at all levels of decision-making in political, economic and public life.
6.1	By 2030, achieve universal and equitable access to safe and affordable drinking water for all.
6.5	By 2030, implement Integrated Water Resources Management (IWRM) at all levels, including through transboundary cooperation as appropriate.
7.1	By 2030, ensure universal access to affordable, reliable and modern energy services.
7.2	By 2030, increase substantially the share of renewable energy in the global energy mix.
7.3	By 2030, double the global rate of improvement in energy efficiency.
8.5	By 2030, achieve full and productive employment and decent work for all women and men, including for young people and persons with disabilities, and equal pay for work of equal value.
8.8	Protect labour rights and promote safe and secure working environments for all workers, including migrant workers, in particular women migrants, and those in precarious employment.
9.3	Increase the access of small-scale industrial and other enterprises, in particular in developing countries, to financial services, including affordable credit, and their integration into value chains and markets.
9.4	By 2030, upgrade infrastructure and retrofit industries to make them sustainable, with increased resource-use efficiency and greater adoption of clean and environmentally sound technologies and industrial processes, with all countries taking action in accordance with their respective capabilities.
10.1	By 2030, progressively achieve and sustain income growth of the bottom 40 per cent of the population at a rate higher than the national average.
10.2	By 2030, empower and promote the social, economic and political inclusion of all, irrespective of age, sex, disability, race, ethnicity, origin, religion or economic or other status.
11.1	By 2030, ensure access for all to adequate, safe and affordable housing and basic services and upgrade slums.
11.7	By 2030, provide universal access to safe, inclusive and accessible, green and public spaces, in particular for women and children, older persons and persons with disabilities.
12.5	By 2030, substantially reduce waste generation through prevention, reduction, recycling and reuse.
12.6	Encourage companies, especially large and transnational companies, to adopt sustainable practices and to integrate sustainability information into their reporting cycle.

13.2	Integrate climate change measures into national policies, strategies and planning.
13.3	Improve education, awareness-raising and human and institutional capacity on climate change mitigation, adaptation, impact reduction and early warning.
14.1	By 2025, prevent and significantly reduce marine pollution of all kinds, in particular from land-based activities, including marine debris and nutrient pollution.
14.5	By 2020, conserve at least 10 per cent of coastal and marine areas, consistent with national and international law and based on the best available scientific information.
15.1	By 2020, ensure the conservation, restoration and sustainable use of terrestrial and inland freshwater ecosystems and their services, in particular forests, wetlands, mountains and drylands, in line with obligations under international agreements .
15.7	Take urgent action to end poaching and trafficking of protected species of flora and fauna and address both demand and supply of illegal wildlife products.
16.1	Significantly reduce all forms of violence and related death rates everywhere
16.4	By 2030, significantly reduce illicit financial and arms flows, strengthen the recovery and return of stolen assets and combat all forms of organized crime.

Source: Own elaboration.

This section intends to present the application of the structural analysis method in two steps, which will be presented in the next subsections. The first subsection is going to set the structural matrix, which is a system of direct interactions. Then, the second section is responsible to analyze the propagation of the indirect interactions through the web of variables (targets).

5.3.1. Investigating direct and indirect interactions between global targets

Once the amount of targets was selected, it is possible to generate the matrix of direct interrelations. This matrix consists in a web of direct relations in terms of influence and dependence. As explained in the chapter 4, each target should be crossed with all the others, by following the guiding question:

If progress is made on target i (rows), how this influences progress on target j (columns)? The answers should be delivered according to the seven-pointed typology from Nilsson *et al.* (2016) presented already in the figure 4.3.

The specialists who judged this procedure used as basis for discussion some results presented in the work produced by Weitz *et al.* (2017) and by Nilsson *et al.* (2016) and ICSU (2017).

Analysing some direct interactions were very obvious process as the example between the targets 1.1 and 10.1. The eradication of extreme poverty (target 1.1) and levering the income of the bottom 40% of the population (target 10.1) are obviously indivisible.

Nonetheless, this analysis was not always easy, as a matter of fact, it demanded a very complex interpretation, and it also brought some subjectivity. The necessity to progress on the targets 7.2 (increase the share of renewable energy in the energy mix) and 7.3 (energy efficiency) can both enable or constrain the target 8.5 (full and productive employment for all). It depends on whether the

mining workers are going to be submitted to a smooth transition, by receiving proper training to keep track of the transitions (ICSU, 2017). The progress made on the target 14.5 (increase protection on the costal and marine areas) can be a problem to the fisheries used to have their works and their nourishment from this area. On the other hand, it can be an opportunity to incentive sustainable fishing practices as well as the area recovery can increase the amount of marine animals in the region. The figure 5.1 presents the results the analysis of the direct interactions, it is based on the scale presented in the chapter 2 (Table 2.1).

Matrix	1.1	1.3	2.1	2.4	3.3	3.8	4.1	4.2	5.2	5.5	6.1	6.5	7.1	7.2	7.3	8.5	8.8	9.3	9.4	10.1	10.2	11.1	11.7	12.5	12.6	13.2	13.3	14.1	14.5	15.1	15.7	16.1	16.4	Sum
1.1		3	3	0	1	2	1	1	1	0	1	0	1	0	0	0	0	0	0	3	3	1	0	1	0	0	1	1	0	1	1	3	3	32
1.3	0		0	0	1	0	1	0	2	1	1	0	1	0	0	1	0	2	0	3	3	2	0	1	0	0	3	0	0	1	0	0	1	24
2.1	3	0		0	2	0	3	3	2	2	2	0	-1	-1	2	3	0	0	0	3	1	0	0	1	0	-2	1	0	0	1	0	0	0	25
2.4	1	0	2		2	0	0	1	0	0	3	2	1	-1	0	0	1	0	2	0	0	0	0	1	1	1	3	2	1	2	1	0	0	26
3.3	0	0	0	0		0	1	1	0	0	0	1	0	0	0	2	1	0	0	1	0	0	0	0	0	0	0	0	0	1	0	0	0	8
3.8	2	0	0	0	2		0	0	0	0	1	0	0	0	0	2	2	0	0	1	1	0	0	0	0	2	1	1	0	0	1	3	1	20
4.1	2	1	1	0	0	0		0	1	0	1	0	0	0	0	2	1	0	0	2	2	0	1	0	0	0	3	0	1	2	0	2	0	22
4.2	2	0	1	1	2	0	3		1	0	0	0	0	0	0	2	0	0	0	3	1	2	0	0	0	0	1	0	0	1	0	0	0	20
5.2	0	0	2	0	2	1	1	1		3	0	0	0	0	0	3	3	0	0	2	3	2	1	0	0	0	0	0	0	0	0	3	1	28
5.5	0	3	2	2	0	0	2	0	3		1	1	0	0	0	2	2	0	0	1	2	1	2	1	1	0	0	0	0	0	0	1	0	27
6.1	1	0	3	1	3	3	2	1	0	1		2	0	-1	1	1	1	0	1	0	1	2	1	1	1	1	1	3	1	3	0	0	0	35
6.5	0	0	1	0	0	0	0	0	0	0	2		2	-1	0	0	0	0	1	0	0	-1	0	1	0	1	2	3	0	1	0	0	0	12
7.1	1	0	2	2	1	0	0	0	0	0	1	1		1	1	1	0	1	1	2	0	2	0	0	2	0	0	0	0	0	0	0	0	19
7.2	0	0	-1	1	0	0	0	0	0	0	2	-1	2		-1	1	0	1	2	2	0	1	0	0	2	3	2	0	0	1	0	0	1	18
7.3	0	0	2	1	0	0	0	0	0	0	2	0	1	-1		0	0	1	3	0	0	1	0	3	2	3	2	0	0	0	0	0	0	20
8.5	3	2	3	0	2	3	1	2	1	2	0	0	1	0	0		1	0	1	2	2	1	0	1	0	0	0	0	0	0	0	2	1	31
8.8	0	0	1	1	3	3	0	0	2	2	0	0	0	0	0	1		0	0	2	2	1	0	0	2	0	0	0	0	0	0	1	1	22
9.3	1	0	2	0	0	1	0	0	0	1	0	0	1	1	1	0	1		2	2	1	0	0	1	2	2	1	0	0	0	0	0	0	20
9.4	0	0	0	1	0	0	0	0	0	0	2	1	1	1	2	1	0	0		1	0	1	0	1	2	3	1	1	0	0	0	0	0	19
10.1	3	0	3	0	2	3	0	3	2	1	0	0	0	0	0	0	1	1	0		3	1	1	0	1	0	1	0	-1	0	1	2	0	28
10.2	3	1	2	0	1	2	1	1	3	2	1	0	1	0	0	2	2	2	0	3		1	1	1	1	0	2	2	0	0	1	3	3	42
11.1	0	1	0	0	2	3	0	2	2	0	2	0	2	0	1	1	1	0	1	0	3		0	0	0	-1	1	0	-2	1	1	2	0	23
11.7	0	0	0	0	1	3	1	0	0	2	2	0	1	0	0	0	0	0	0	1	2	0		0	0	0	1	1	1	1	0	1	1	19
12.5	0	0	1	1	2	3	0	0	0	0	2	1	1	1	1	2	1	1	1	1	0	0	1		2	2	2	2	0	3	0	1	1	33
12.6	0	0	0	1	3	3	0	0	0	0	3	0	2	2	3	0	2	2	2	2	1	0	0	2		2	2	2	0	2	0	0	0	36
13.2	0	-1	1	1	2	1	0	0	0	0	2	0	2	1	2	0	0	2	1	0	0	-1	0	1	2		3	1	-2	3	0	2	0	23
13.3	1	1	1	3	2	2	3	1	0	0	2	2	0	2	2	0	0	1	1	0	2	0	0	2	1	3		1	0	2	0	1	0	36
14.1	0	0	3	1	2	3	0	0	0	0	3	2	0	0	0	0	0	0	0	0	0	0	0	2	0	0	1		3	1	0	0	0	21
14.5	-1	-1	1	1	2	1	0	0	0	0	1	0	0	0	0	0	0	0	0	-1	0	-1	0	0	0	1	1	1		0	0	0	0	5
15.1	1	-2	-1	2	3	3	0	0	0	0	3	2	0	2	1	0	0	0	0	0	0	0	0	1	0	3	1	3	0		1	1	1	25
15.7	-1	0	0	1	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	3		1	2	7
16.1	0	0	0	0	2	3	1	0	3	1	1	0	0	0	0	0	1	0	0	0	2	0	0	0	0	0	0	0	0	1	0		3	18
16.4	-1	1	0	1	0	2	0	0	2	1	0	0	0	0	0	2	1	0	0	0	1	1	0	0	0	0	0	1	0	2	2	3		19
Sum	21	9	35	22	45	46	21	17	25	19	41	14	19	6	16	29	22	14	19	36	36	17	8	22	22	24	37	25	2	33	9	32	20	

Scale: Indivisible (+3) ; Reinforcing (+2); Enabling (+1); Consistent (0); Constraining (-1); Counteracting (-2); Cancelling (-3)

Figure 5.1 - Cross-impact matrix of selected global targets

After concluding the analysis of the interactions between the 33 targets, the specialists discussed that in future works, the fuzzy linguistic approach should be also included in this stage. As explained in the chapter 4, the bigger the target`s row-sum, the more influent the target is. The top influent five targets with the highest row-sums are 10.2 (social inclusion), 12.6 (integration of sustainable practices in companies), 13.3 (improve education and capacity on climate change), 6.1 (drinking water for all) and 12.5 (reduce waste generation). From those targets, the 6.1 and 13.3 are also among the top-five most dependent ones.

As it was explained in the chapter 4, the direct relations provide an immediate impact on the system, which means a short time horizon impact. While the targets with the high column-sum are reliant on the progress of other targets, the targets with high row-sum are the ones that will determinate the courses of the system as a whole. However, it is essential to simultaneously evaluate the row-sum and the column-sum. For example, the highly influent and influenced targets, such as the 6.1 and 13.3 ones, must be under an especial attention. Always when one of the multiple targets that have influence on them makes progress or steps backwards, a huge impact (positive or negative) will be generated on the system as whole. The chain reactions of the targets systems will be further discussed in the next subsection.

It is important to highlight that even though the high row-sum of a target means that a target has a high positive influence, it does not exclude the fact that this target can also exert negative impact on another one. For example, making progress on the target 6.1 (drinking water for all) can be very positive to many targets, but it exerts negative impact on the hydropower sector, which in the Brazilian case, it is the highest renewable energy share in the mix of energy (target 7.2).

These results provided by the analysis of the web of direct relations are already a very useful tool to assist the decision makers to implement the 2030 Agenda at national level, especially when it comes to short-time horizon consequences. The next subsection will explore the consequences of this web of interaction in further time-horizon through the identification of the indirect relations. This is going to be the decisive step to the determining the key targets that should be prioritized in 2030 Agenda implementation.

5.3.2.
Identifying the determinant, relay, and resultant global targets in the Brazilian context

After the generation of the matrix of direct impacts, it is possible to start to investigate the indirect relations between variables (targets). In order to carry on this analysis, the power of the matrix needs to be levered until their row-sum and column-sum rankings remain stable. This stability will be achieved when each element incorporates the propagation of the indirect relations.

During the application of this methodology, it was possible to observe the fluctuations of the row-sum and column-sum rankings until the matrix achieved the power of five (the row-sum and column-sum rankings were finally stable). This means that the variables (targets) interact among themselves in a path of length 5. The influence of some targets was revealed when the chain propagation was integrated; this has significantly altered the row-sum ranking. The targets that occupy the top positions in row-sum ranking are the ones that in a long term will propagate more chain influence.

However, the global influence and dependence scores are not enough information to identify the key targets to be implemented. Both row-sum and column-sum need to be simultaneously analysed in a graph dependence x influence. Figures 5.2 and 5.3 respectively shows the overview influence x dependence of the direct and indirect relations between targets.

The targets 14.5 (costal and marine protection), 15.7 (ending trafficking of fauna and flora) and 6.5 (Integration Water Resources Management - IWRM) have a very low influence and dependence, their progress are not determined by the system; they bring low impact on the system as a whole. That is why they are considered autonomous variables. By analysing the figures 5.2 and 5.3, it is possible to notice that the incorporation of the chain reactions didn't alter their role in the system. Their low connection to the system does not mean that the implementation of those targets is less important, it means that making progress on them is not going to impact the system as a whole.

The most influent and less dependent targets are the key ones to be implemented since they are the driving forces of the system. Any breakthrough or step backwards is going to affect the whole web of interactions. The targets 12.6(integration of sustainable practices in companies), 12.5 (reduce waste generation), 5.5 (women`s participation in decision making) and 2.4 (sustainable food production) reinforced their roles as determinant variables when the chain reactions were incorporated by the system. Regarding the targets 1.3

(implementation of social protection systems), 11.1 (upgrading slums),13.2 (integration of climate change into national policy) and 4.1 (effective conclusion of secondary education), it is possible to conclude that their influence is going to increase in a long term; the exploration of their indirect relations brought them into evidence. On the other hand, it is showed that the target 1.1 (extreme poverty eradication) gets much more dependent on the others within time, since it adopted a relay variable role.

The relay targets are the ones with high dependence and high influence; this means that whenever they are affected by other targets (this happens quite often) they are going to propagate the effect to the whole system. From the mathematic perspective, their duty is to keep the variables connected. The middle cluster variables have a similar function, however they don`t impact and are impacted so often. They can be also addressed as regulating variables, since the progress made on them can smooth possible negative consequences provided by the determinant and the relay variables.

The resultant variables are highly sensitive to the influences caused by the system. The targets 16.1 (reduce all forms of violence), 3.3 (end epidemics) and 3.8 (universal health coverage) are highly susceptible to the direct and indirect effects of the system. It does not mean that these targets can be fully achieved if the others are, but it does mean that significant progress is going to be made on them whenever the system evolve as a whole.

The roles performed by the target 15.1 (environmental conservation and restoration), which moved from the relay variables sector to the resultant variables sector, show that the isolated policies and programs for environmental protection are not going to be enough to make progress on this target.

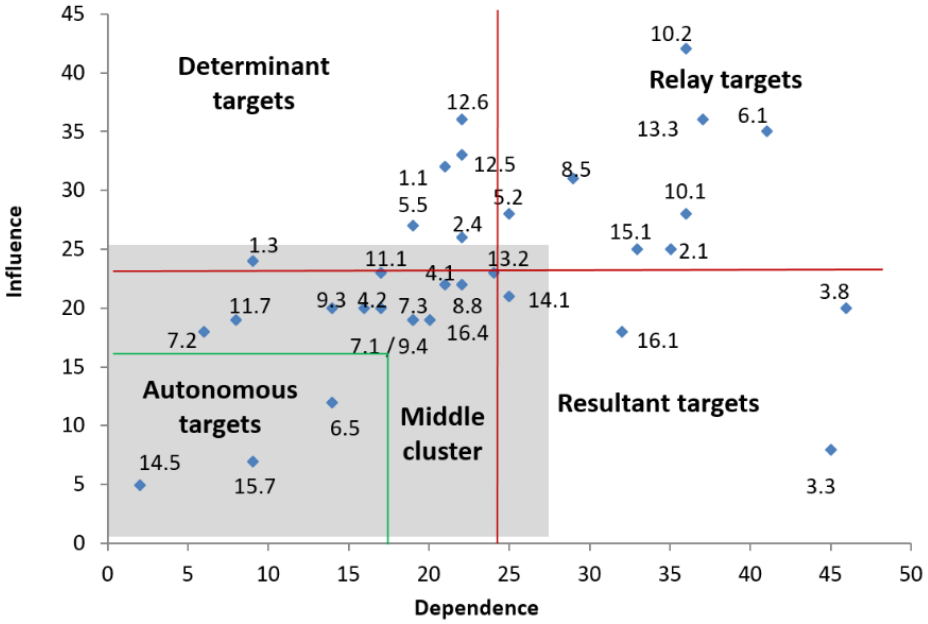


Figure 5.2 - Influence *versus* dependence graph of direct relations

Source: Own elaboration.

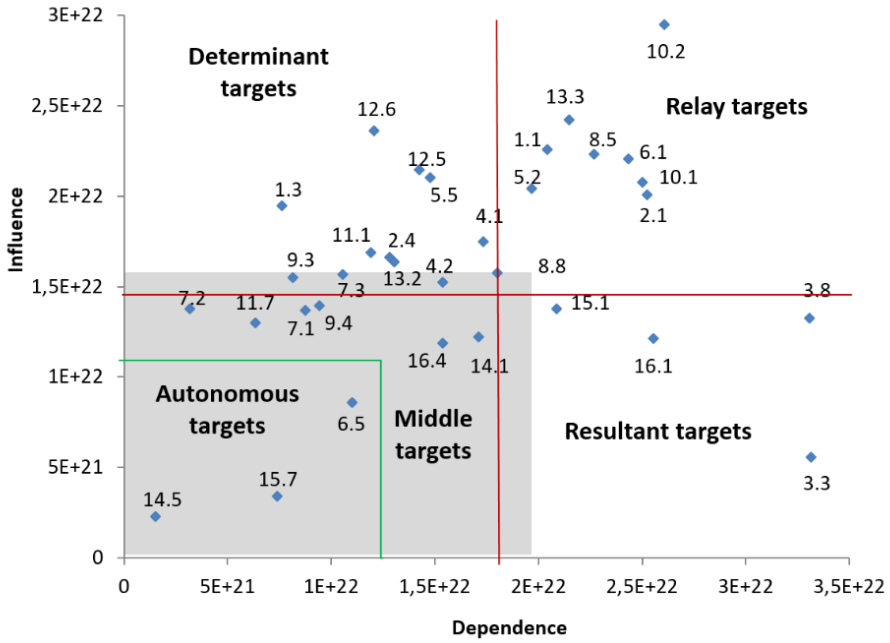


Figure 5.3 - Influence *versus* dependence graph of indirect relations

Source: Own elaboration.

After identifying the different roles of the variables in the system, it will be possible to start the investigation of how a target impacts its own cluster.

5.4.
Phase IV: network analysis for visualization of indirect interactions of global targets in the Brazilian context

The generation of network graphs offers the opportunity for systematic investigation and theorizing on the structure of ties among variables. It is important to highlight that this section will graphically analyze the web of indirect relations. Then, differently from a web of direct relations (matrix of power of 1), all variables are related to all the others. Each element in the matrix of power of 5 shows the intensity of the connections between a pair of variables, however only through a very complex network analysis it would be possible to identify intermediary connectors, which will be investigated in a future studies.

The figure 5.4 presents an overview of the chain propagation of indirect interactions between global targets. This was generated with the software Gephi (2009)[2] and it shows the nodes and their connections randomly aligned. The variables were grouped in five clusters (according to the figure 5.4). On this graph it was used the edge weight tool, its application increases the size of the nodes according with their degree of intensity (Jacomy *et al*., 2014); the bigger the node, the more intensively a target is connected. This graph shows that the relay variables (highest influence and highest dependence) have the biggest nodes, which means that they have the most intense connections.

This cluster was colored with orange, and it is also possible to note the predominant quantity of oranges lines in the graph. On the other hand, the autonomous variables cluster (low dependence and low influence) contains the smallest nodes of the system; they are marked with yellow color. Most of the purple nodes have average size, which is consistent, since they belong to the middle variables cluster. Then, both the determinant variables cluster (green color) and the resultant variables cluster (blue color) have big nodes that represent their high intensity of connections.

[2]https://gephi.org/

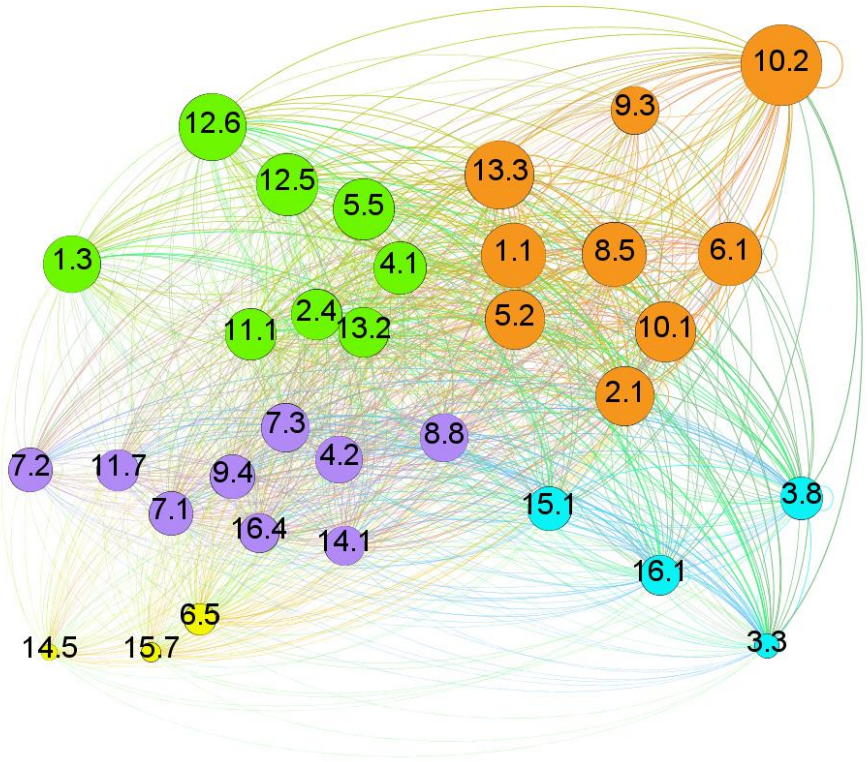


Figure 5.4 – Network overview of all indirect interactions of the prioritized global targets in the Brazilian context

Notation: Yellow - autonomous targets; purple – middle cluster targets; blue – resultant targets; green – determinant targets; orange – relay targets. Direct density: 1,034. Indirect density: 1,069.

The implementation of the 2030 Agenda at national level must be done with basis on the two last presented visualisations. While the chart (figure 5.3) is showing the role of each variable in the system, the graphic (figure 5.4) shows the intensity of this role to the system as a whole.

In order to provide a visualization able to convey a more useful information, it was plotted three separated networks graphs. They correspond to the three clusters, which have the most intense relation with the system as a whole. The graphics will be respectively presented in the three next figures.

As it was previously explained, the relay variables are the ones who determinate the direction of the system, then they can be seen as driving forces. Among all of them (figure 5.5), the target 12.5 is the one that is most intensely connected, which can work as center of gravity, connecting the targets together. It is very coherent, once the 12.5 is a target related to the reduction of waste generation. The implementation of this target generates a huge chain impact

especially with the targets 12.6 (sustainable practices in enterprises), 2.4 (sustainable food production) and 11.1 (upgrading slams).

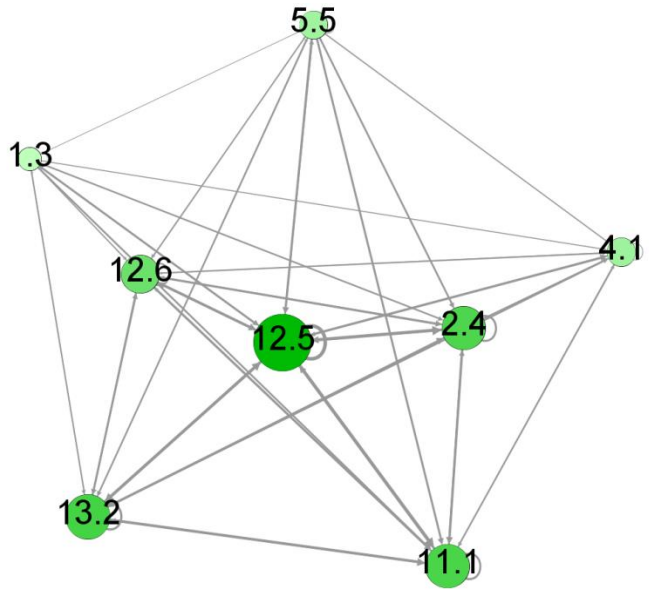


Figure 5.5 – Graph of the determinant global targets' cluster in the Brazilian context

The center of gravity of the relay targets are the targets 13.3 (education and capacity on climate change) and 6.1 (drinking water for all) (figure 5.6). It is interesting to note that the target 10.2 (social inclusion) was the most intensively connected in global network. However, this variable does not play as a high intensity connector in this subnetwork.

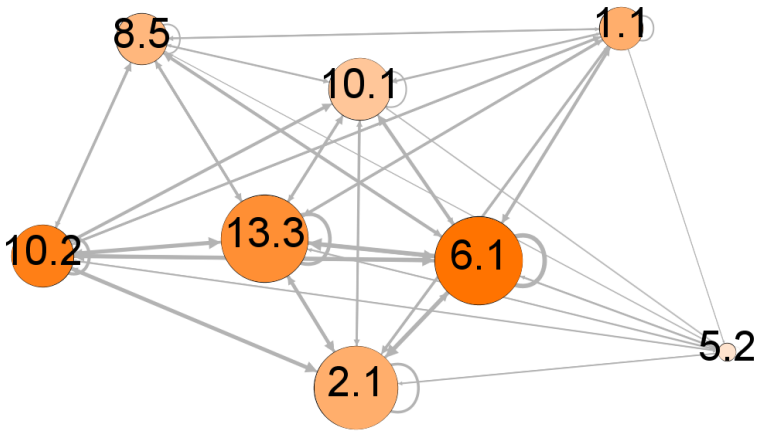


Figure 5.6 – Graph of the relay global targets' cluster in the Brazilian context

The target 15.1 (environmental conservation and restoration) works the gravity center to this subnetwork. The ticker the edge, the stronger the connections

are (figure 5.7). The graph shows that the target 15.1 influences much more than it is influenced, which is coherent with the chart in figure 5.3.

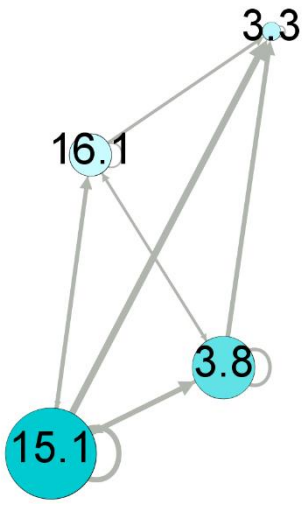


Figure 5.7 – Graph of the resultant global targets' cluster in the Brazilian context

As it was already early explained in this chapter, these results are an initial mathematical experiment, due to this it is not possible to go deeper in discussions about the targets with the biggest degree of interactions. The application of the fourth phase of the model was fundamental for a first use of the software.

5.5. Final remarks on the preliminary experiment

This chapter has described and discussed the results of a preliminary experiment focusing the application of the conceptual model in a 'laboratorial' environment. The quantitative tools integrated in this model entirely correspond with the specialists expectations.

This preliminary experiment was fundamental for adjusting and improving the model reported in chapter 4. As it was explained in the section 5.1, the criterion C4 ('resources' availability for the target implementation') was excluded after the results of the experiment. This criterion should be used in a subsequent phase of this model application. In addition, during the experiment it was also possible to improve the scales and guarantee its accuracy.

Moreover, the comparison between the crisp and fuzzy rankings drove to the conclusion that the recognition of the subjectivity may slightly affect the results. After applying the fuzzy-TOPSIS to all of the sixteen SDGs, the results were not conclusive. But the intention, as mentioned before, was test the model and not

determine the key global targets that should be included in the Brazilian 2030 Agenda.

It must be highlighted that the fuzzy-AHP-TOPSIS method can be a powerful tool to be incorporated in the first step of the structural analysis, which is related to the selection of global targets. This multicriteria method can collect opinions from different perspectives and consider, at the same time, their imprecision and uncertainty; and at the end, a ranking, conducted in the light of coherently weighted criteria, is provided.

This chapter also brought important contributions to the work developed by Weitz *et* al (2017) in Sweden, by showing the effects of the propagation of the indirect relations when the time-horizon exceed 10 years. The structural analysis can reveal the interactions of global targets within the time-horizon of the Agenda 2030. The tests developed with the software Gephi proved that this tool was an assertive choice for the further visualization of results obtained from the structural analysis (clusters of determinant, relay and resultant global targets).

Finally, this chapter proved that the main objective of this dissertation, which consisted in proposing a systemic conceptual model to prioritize the global targets associated with the SDGs at the country level was achieved.

6
Conclusions

The systemic conceptual model proposed in this dissertation proved itself to be an effective tool to help countries to define their priorities concerning the global targets of 2030 Agenda. Then, it is possible to conclude that the general objective of this study was achieved.

The results of the integration of the structural analysis and network theory to the multicriteria methodological approach also revealed themselves to be effective tools to map and evidence the key targets that are going to determine the success (or not) of the implementation of the 2030 Agenda at the national level. It allows identify which global targets are the most influent and less dependent ones in relation to the remaining targets. Complementing this analysis, the network graphs allow the visualization of the intensity of the web of interactions for the whole set of prioritized global targets, and also for the three clusters generated by structural analysis, i.e. determinant, relay and resultant global targets.

After identifying reference works and methodological approaches with the potential to be applied during the modelling phase of this research, the fuzzy-AHP-TOPSIS method was chosen to integrate the first and second phases of the conceptual model. The application of the structural analysis, as proposed by Godet (1994) started with the mapping of interactions between the SDGs of Brazil, up to the level of its respective targets. The direct relations were analyzed with the use of the scale proposed by Nilsson *et al.*(2016). The combination of the structural analysis with the scale proposed by Nilsson *et al.* can be considered an innovative feature of the proposed model in relation to the methods adopted in Sweden, for example (Weitz, 2017).

The specialists who participated of the preliminary experiment could suggest significant adjustments in the model during the applied phase of this research. This experiment foresees the conception of a Brazilian case study. Multistakeholders should be invited to evaluate the global targets according with the guidelines of the conceptual model presented in the chapter 4.

During the development of the preliminary experiment, the specialists also noticed the subjectivity during the judgments about the direct interactions between the global targets (fulfillment of direct impact matrix of the structural analysis). By

acknowledging it, this study recommends the incorporation of the fuzzy linguistic approach in the structural analysis phase of this model.

The analysis of the causal chain proposed by this model considers time-horizons higher than 10 years, which corresponds exactly to the time-horizon of the 2030 Agenda. This is also a differential of the model in relation to the methods reported in previous works regarding Agenda 2030, that makes it a strategic methodological approach to assist different stakeholders (policy makers, academicians, representatives of the private sector; non-governmental organizations, and other segments of the society) to implement a 2030 Agenda for Sustainable Development at the national level.

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Appendix 1 – Results from the preliminary experiment in the Brazilian context: application of fuzzy AHP-TOPSIS

SDG 1

SDG 1	Fuzzy decision matrix														
	1.1			1.2			1.3			1.4			1.5		
	l	m	u	l	m	u	l	m	u	l	m	u	l	m	u
C1	2	3	3	2	3	3	2	3	3	1	2	3	0	1	2
C2	2	3	3	2	3	3	1	2	3	1	2	3	0	1	2
C3	1	2	3	0	1	2	1	2	3	1	2	3	1	2	3
C4	1	2	3	0	1	2	0	1	2	0	1	2	0	1	2

SDG 1	FPIS	FNIS		Final Ranking	
	D+	D-	CCi	Fuzzy	Crisp
1.1	2,493	2,500	0,501	1.1	1.1
1.2	2,728	2,076	0,456	1.3	1.2
1.3	2,690	2,259	0,442	1.4	1.3
1.4	2,790	2,211	0,432	1.2	1.4
1.5	3,013	1,789	0,373	1.5	1.5

SDG 2

SDG 2	Fuzzy decision matrix														
	2.1			2.2			2.3			2.4			2.5		
	l	m	u	l	m	u	l	m	u	l	m	u	l	m	u
C1	2	3	3	1	2	3	0	1	2	2	3	3	1	2	3
C2	1	2	3	1	2	3	1	2	3	0	1	2	0	0	1
C3	1	2	3	0	0	1	1	2	3	1	2	3	1	2	3
C4	0	1	2	1	2	3	1	2	3	2	3	3	1	2	3

SDG 2	FPIS	FNIS		Final Ranking	
	D+	D-	CCi	Fuzzy	Crisp
1.1	2,690	2,259	0,456	2.4	2.4
1.2	2,883	2,020	0,412	2.1	2.1
1.3	2,790	2,211	0,442	2.3	2.2
1.4	2,556	2,321	0,476	2.5	2.3
1.5	2,867	2,024	0,414	2.2	2.5

SDG 3

SDG 3	Fuzzy decision matrix														
	3.1			3.2			3.3			3.4			3.5		
	l	m	u	l	m	u	l	m	u	l	m	u	l	m	u
C1	2	3	3	2	3	3	2	3	3	1	2	3	0	1	2
C2	1	2	3	1	2	3	2	3	3	1	2	3	0	1	2
C3	0	0	1	0	1	2	0	1	2	0	0	1	2	3	3
C4	2	3	3	1	2	3	2	3	3	0	1	2	0	1	2

SDG 3	Fuzzy decision matrix											
	3.6			3.7			3.8			3.9		
	l	m	u	l	m	u	l	m	u	l	m	u
C1	1	2	3	2	3	3	2	3	3	2	3	3
C2	0	1	2	1	2	3	1	2	3	0	1	2
C3	0	0	1	0	0	1	2	3	3	2	3	3
C4	0	1	2	1	2	3	1	2	3	0	1	2

SDG 3	FPIS	FNIS		Final Ranking
	D+	D-	CCi	Fuzzy
3.1	2,684	2,117	0,441	3.8
3.2	2,667	2,269	0,460	3.3
3.3	2,499	2,342	0,484	3.2
3.4	3,012	1,803	0,374	3.1
3.5	2,933	1,819	0,383	3.9
3.6	3,107	1,599	0,3398	3.7
3.7	2,784	2,069	0,4263	3.5
3.8	2,481	2,506	0,5026	3.4
3.9	2,704	2,085	0,4354	3.6

SDG 4

SDG 4	Fuzzy decision matrix											
	4.1			4.2			4.3			4.4		
	l	m	u	l	m	u	l	m	u	l	m	u
C1	2	3	3	2	3	3	2	3	3	2	3	3
C2	2	3	3	2	3	3	0	1	2	0	1	2
C3	1	2	3	1	2	3	1	2	3	1	2	3
C4	2	3	3	2	3	3	1	2	3	0	1	2

SDG 4	Fuzzy decision matrix								
	4.5			4.6			4.7		
	l	m	u	l	m	u	l	m	u
C1	0	1	2	2	3	3	1	2	3
C2	1	2	3	2	3	3	0	1	2
C3	1	2	3	0	0	1	1	2	3
C4	0	1	2	2	3	3	0	1	2

SDG 4	FPIS	FNIS		Final Ranking
	D+	D-	CCi	Fuzzy
4.1	2,393	2,549	0,516	4.1
4.2	2,393	2,549	0,516	4.2
4.3	2,655	2,272	0,461	4.3
4.4	2,784	2,055	0,425	4.6
4.5	2,919	1,994	0,406	4.4
4.6	2,616	2,141	0,4502	4.7
4.7	2,884	2,006	0,4103	4.5

SDG 5

SDG 5	Fuzzy decision matrix																	
	5.1			5.2			5.3			5.4			5.5			5.6		
	l	m	u	l	m	u	l	m	u	l	m	u	l	m	u	l	m	u
C1	1	2	3	2	3	3	0	0	1	1	2	3	2	3	3	2	3	3
C2	1	2	3	1	2	3	0	0	1	0	1	2	0	1	2	1	2	3
C3	1	2	3	1	2	3	2	3	3	1	2	3	2	3	3	0	0	1
C4	0	1	2	0	1	2	0	0	1	0	1	2	1	2	3	1	2	3

SDG 5	FPIS	FNIS		Final Ranking
	D+	D-	CCi	Fuzzy
5.1	2,790	2,211	0,442	5.5
5.2	2,690	2,259	0,456	5.2
5.3	3,308	1,207	0,267	5.1
5.4	2,884	2,006	0,410	5.6
5.5	2,575	2,302	0,472	5.4
5.6	2,784	2,069	0,4263	5.3

SDG 6

SDG 6	Fuzzy decision matrix																	
	6.1			6.2			6.3			6.4			6.5			6.6		
	l	m	u	l	m	u	l	m	u	l	m	u	l	m	u	l	m	u
C1	2	3	3	0	1	2	2	3	3	2	3	3	1	2	3	2	3	3
C2	1	2	3	0	1	2	0	1	2	0	1	2	1	2	3	0	1	2
C3	0	1	2	0	1	2	0	1	2	0	0	1	0	1	2	0	1	2
C4	1	2	3	1	2	3	2	3	3	0	1	2	1	2	3	1	2	3

SDG 6	FPIS	FNIS		Final Ranking
	D+	D-	CCi	Fuzzy
6.1	2,618	2,466	0,485	6.1
6.2	2,941	1,996	0,404	6.5
6.3	2,613	2,310	0,469	6.3
6.4	2,970	1,744	0,370	6.6
6.5	2,718	2,417	0,471	6.2
6.6	2,712	2,262	0,4547	6.4

SDG 7

SDG 7	Fuzzy decision matrix								
	7.1			7.2			7.3		
	l	m	u	l	m	u	l	m	u
C1	2	3	3	2	3	3	2	3	3
C2	0	1	2	1	2	3	0	1	2
C3	0	0	1	0	0	1	0	0	1
C4	2	3	3	2	3	3	2	3	3

SDG 7	FPIS	FNIS		Final Ranking
	D+	D-	CCi	Fuzzy
7.1	2,692	2,298	0,461	7.2
7.2	2,598	2,502	0,491	7.1
7.3	2,692	2,298	0,461	7.3

SDG 8

SDG 8	Fuzzy decision matrix														
	8.1			8.2			8.3			8.4			8.5		
	l	m	u	l	m	u	l	m	u	l	m	u	l	m	u
C1	1	2	3	1	2	3	2	3	3	2	3	3	2	3	3
C2	1	2	3	0	1	2	1	2	3	0	1	2	1	2	3
C3	2	3	3	2	3	3	2	3	3	2	3	3	2	3	3
C4	1	2	3	1	2	3	0	1	2	0	1	2	1	2	3

SDG 8	Fuzzy decision matrix														
	8.6			8.7			8.8			8.9			8.10		
	l	m	u	l	m	u	l	m	u	l	m	u	l	m	u
C1	1	2	3	1	2	3	2	3	3	0	1	2	2	3	3
C2	0	1	2	1	2	3	1	2	3	0	1	2	2	3	3
C3	2	3	3	1	2	3	2	3	3	2	3	3	0	1	2
C4	0	1	2	1	2	3	2	3	3	0	1	2	2	3	3

SDG 8	FPIS	FNIS		Final Ranking
	D+	D-	CCi	Fuzzy
8.1	2,580	2,458	0,488	8.8
8.2	2,675	2,253	0,457	8.5
8.3	2,610	2,289	0,467	8.1
8.4	2,704	2,085	0,435	8.7
8.5	2,481	2,506	0,503	8.3
8.6	2,804	2,036	0,4207	8.2
8.7	2,661	2,428	0,4771	8.9
8.8	2,381	2,555	0,5176	8.4
8.9	2,933	2,342	0,444	8.10
8.10	2,499	1,819	0,4212	8.6

SDG 9

SDG 9	Fuzzy decision matrix														
	9.1			9.2			9.3			9.4			9.5		
	l	m	u	l	m	u	l	m	u	l	m	u	l	m	u
C1	1	2	3	2	3	3	2	3	3	1	2	3	2	3	3
C2	0	1	2	0	1	2	1	2	3	1	2	3	0	1	2
C3	1	2	3	1	2	3	1	2	3	1	2	3	1	2	3
C4	0	1	2	1	2	3	2	3	3	2	3	3	1	2	3

SDG 9	FPIS	FNIS		Final Ranking
	D+	D-	CCi	Fuzzy
9.1	2,884	2,006	0,410	9.3
9.2	2,655	2,272	0,461	9.4
9.3	2,461	2,525	0,506	9.2
9.4	2,561	2,477	0,492	9.5
9.5	2,655	2,272	0,461	9.1

SDG 10

SDG 10	Fuzzy decision matrix											
	10.1			10.2			10.3			10.4		
	l	m	u	l	m	u	l	m	u	l	m	u
C1	2	3	3	1	2	3	1	2	3	1	2	3
C2	1	2	3	1	2	3	0	1	2	0	1	2
C3	2	3	3	2	3	3	2	3	3	2	3	3
C4	1	2	3	1	2	3	1	2	3	0	1	2

SDG 10	Fuzzy decision matrix								
	10.5			10.6			10.7		
	l	m	u	l	m	u	l	m	u
C1	2	3	3	2	3	3	1	2	3
C2	0	1	2	0	1	1	0	1	2
C3	2	3	3	2	3	3	2	3	3
C4	0	1	2	0	1	2	0	1	2

SDG 10	FPIS	FNIS		Final Ranking
	D+	D-	CCi	Fuzzy
10.1	2,481	2,506	0,503	10.1
10.2	2,580	2,458	0,488	10.2
10.3	2,675	2,253	0,457	10.3
10.4	2,804	2,036	0,421	10.5
10.5	2,704	2,085	0,435	10.4
10.6	2,771	1,899	0,4066	10.7
10.7	2,804	2,036	0,4207	10.6

SDG 11

SDG 11	Fuzzy decision matrix											
	11.1			11.2			11.3			11.4		
	l	m	u	l	m	u	l	m	u	l	m	u
C1	2	3	3	2	3	3	1	2	3	2	3	3
C2	1	2	3	0	1	2	0	1	2	0	1	2
C3	0	1	2	0	1	2	0	1	2	0	1	2
C4	1	2	3	0	1	2	1	2	3	1	2	3

SDG 11	Fuzzy decision matrix								
	11.5			11.6			11.7		
	l	m	u	l	m	u	l	m	u
C1	1	2	3	2	3	3	2	3	3
C2	0	1	2	0	1	2	1	2	3
C3	0	1	2	0	1	2	0	1	2
C4	0	1	2	1	2	3	1	2	3

SDG 11	FPIS	FNIS		Final Ranking
	D+	D-	CCi	Fuzzy
11.1	2,618	2,466	0,485	11.1
11.2	2,841	2,044	0,418	11.7
11.3	2,812	2,213	0,440	11.4
11.4	2,712	2,262	0,455	11.6
11.5	2,941	1,996	0,404	11.3
11.6	2,712	2,262	0,4547	11.2
11.7	2,618	2,466	0,485	11.5

SDG 12

SDG 12	Fuzzy decision matrix											
	12.1			12.2			12.3			12.4		
	l	m	u	l	m	u	l	m	u	l	m	u
C1	2	3	3	2	3	3	1	2	3	1	2	3
C2	0	1	2	0	1	2	0	1	2	0	1	2
C3	1	2	3	1	2	3	1	2	3	1	2	3
C4	1	2	3	1	2	3	1	2	3	1	2	3

SDG 12	Fuzzy decision matrix											
	12.5			12.6			12.7			12.8		
	l	m	u	l	m	u	l	m	u	l	m	u
C1	2	3	3	2	3	3	2	3	3	1	2	3
C2	1	2	3	1	2	3	0	1	2	0	1	2
C3	1	2	3	1	2	3	1	2	3	1	2	3
C4	1	2	3	2	3	3	1	2	3	1	2	3

SDG 12	FPIS	FNIS		Final Ranking
	D+	D-	CCi	Fuzzy
12.1	2,655	2,272	0,461	12.6
12.2	2,655	2,272	0,461	12.5
12.3	2,755	2,224	0,447	12.1
12.4	2,755	2,224	0,447	12.2
12.5	2,561	2,477	0,492	12.7
12.6	2,461	2,525	0,5064	12.3
12.7	2,655	2,272	0,4611	12.4
12.8	2,755	2,224	0,4466	12.8

SDG 13

SDG 13	Fuzzy decision matrix								
	13.1			13.2			13.3		
	l	m	u	l	m	u	l	m	u
C1	1	2	3	2	3	3	2	3	3
C2	0	1	2	1	2	3	1	2	3
C3	0	1	2	0	1	2	0	1	2
C4	0	1	2	1	2	3	1	2	3

SDG 13	FPIS	FNIS		Final Ranking
	D+	D-	CCi	Fuzzy
13.1	2,941	1,996	0,404	13.2
13.2	2,618	2,466	0,485	13.3
13.3	2,618	2,466	0,485	13.1

SDG 14

SDG 14	Fuzzy decision matrix											
	14.1			14.2			14.3			14.4		
	l	m	u	l	m	u	l	m	u	l	m	u
C1	2	3	3	1	2	3	0	1	2	2	3	3
C2	1	2	3	0	1	2	0	1	2	1	2	3
C3	2	3	3	2	3	3	2	3	3	0	0	1
C4	1	2	3	1	2	3	0	1	2	1	2	3

SDG 14	Fuzzy decision matrix								
	14.5			14.6			14.7		
	l	m	u	l	m	u	l	m	u
C1	2	3	3	1	2	3	0	0	1
C2	1	2	3	0	1	2	0	0	1
C3	2	3	3	2	3	3	2	3	3
C4	1	2	3	1	2	3	0	0	1

SDG 14	FPIS	FNIS		Final Ranking
	D+	D-	CCi	Fuzzy
14.1	2,481	2,506	0,503	14.1
14.2	2,675	2,253	0,457	14.5
14.3	2,933	1,819	0,383	14.2
14.4	2,784	2,069	0,426	14.6
14.5	2,481	2,506	0,503	14.4
14.6	2,675	2,253	0,4573	14.3
14.7	3,308	1,207	0,2674	14.7

SDG 15

SDG 15	Fuzzy decision matrix														
	15.1			15.2			15.3			15.4			15.5		
	l	m	u	l	m	u	l	m	u	l	m	u	l	m	u
C1	2	3	3	2	3	3	0	1	2	1	2	3	2	3	3
C2	0	1	2	0	1	2	0	1	2	0	1	2	0	1	2
C3	2	3	3	1	2	3	1	2	3	1	2	3	0	0	1
C4	1	2	3	1	2	3	0	1	2	1	2	3	1	2	3

SDG 15	Fuzzy decision matrix											
	15.6			15.7			15.8			15.9		
	l	m	u	l	m	u	l	m	u	l	m	u
C1	1	2	3	1	2	3	0	1	2	2	3	3
C2	0	1	2	2	3	3	2	3	3	0	1	2
C3	1	2	3	1	2	3	1	2	3	1	2	3
C4	1	2	3	2	3	3	2	3	3	1	2	3

SDG 15	FPIS	FNIS		Final Ranking
	D+	D-	CCi	Fuzzy
15.1	2,575	2,302	0,472	15.7
15.2	2,655	2,272	0,461	15.1
15.3	3,013	1,789	0,373	15.8
15.4	2,755	2,224	0,447	15.2
15.5	2,878	1,865	0,393	15.9
15.6	2,755	2,224	0,4466	15.4
15.7	2,493	2,500	0,5008	15.6
15.8	2,622	2,283	0,4655	15.5
15.9	2,655	2,272	0,4611	15.3

SDG 16

SDG 16	Fuzzy decision matrix														
	16.1			16.2			16.3			16.4			16.5		
	l	m	u	l	m	u	l	m	u	l	m	u	l	m	u
C1	2	3	3	0	1	2	2	3	3	2	3	3	2	3	3
C2	2	3	3	1	2	3	1	2	3	1	2	3	1	2	3
C3	2	3	3	2	3	3	2	3	3	2	3	3	2	3	3
C4	2	3	3	1	2	3	1	2	3	2	3	3	1	2	3

SDG 16	Fuzzy decision matrix														
	16.6			16.7			16.8			16.9			16.10		
	l	m	u	l	m	u	l	m	u	l	m	u	l	m	u
C1	2	3	3	2	3	3	2	3	3	2	3	3	1	2	3
C2	0	1	2	0	1	3	0	0	1	1	2	3	0	1	2
C3	2	3	3	2	3	3	2	3	3	0	1	2	2	3	3
C4	1	2	3	2	3	3	1	2	3	1	2	3	1	2	3

SDG 16	FPIS	FNIS		Final Ranking
	D+	D-	CCi	Fuzzy
16.1	2,313	2,579	0,527	16.1
16.2	2,709	2,241	0,453	16.4
16.3	2,481	2,506	0,503	16.7
16.4	2,381	2,555	0,518	16.3
16.5	2,481	2,506	0,503	16.5
16.6	2,575	2,302	0,472	16.6
16.7	2,451	2,541	0,509	16.10
16.8	2,687	2,103	0,4391	16.9
16.9	2,667	2,253	0,4579	16.2
16.10	2,675	2,269	0,459	16.8

Annex 1 - Sustainable Development Goals (UN, 2015)

Goal 1. End poverty in all its forms everywhere

1.1 By 2030, eradicate extreme poverty for all people everywhere, currently measured as people living on less than $1.25 a day.
1.2 By 2030, reduce at least by half the proportion of men, women and children of all ages living in poverty in all its dimensions according to national definitions.
1.3 Implement nationally appropriate social protection systems and measures for all, including floors, and by 2030 achieve substantial coverage of the poor and the vulnerable.
1.4 By 2030, ensure that all men and women, in particular the poor and the vulnerable, have equal rights to economic resources, as well as access to basic services, ownership and control over land and other forms of property, inheritance, natural resources, appropriate new technology and financial services, including micro finance.
1.5 By 2030, build the resilience of the poor and those in vulnerable situations and reduce their exposure and vulnerability to climate-related extreme events and other economic, social and environmental shocks and disasters.
1.a. Ensure significant mobilization of resources from a variety of sources, including through enhanced development cooperation, in order to provide adequate and predictable means for developing countries, in particular least developed countries, to implement programmes and policies to end poverty in all its dimensions.
1.b. ·Create sound policy frameworks at the national, regional and international levels, based on pro-poor and gender-sensitive development strategies, to support accelerated investment in poverty eradication actions.

Goal 2. End hunger, achieve food security and improved nutrition and promote sustainable agriculture

2.1 By 2030, end hunger and ensure access by all people, in particular the poor and people in vulnerable situations, including infants, to safe, nutritious and sufficient food all year round.
2.2 By 2030, end all forms of malnutrition, including achieving, by 2025, the internationally agreed targets on stunting and wasting in children under 5 years of age, and address the nutritional needs of adolescent girls, pregnant and lactating women and older persons.
2.3 By 2030, double the agricultural productivity and incomes of small-scale food producers, in particular women, indigenous peoples, family farmers, pastoralists and fishers, including through secure and equal access to land, other productive resources and inputs, knowledge, financial services, markets and opportunities for value addition and non-farm employment.

2.4 By 2030, ensure sustainable food production systems and implement resilient agricultural practices that increase productivity and production, that help maintain ecosystems, that strengthen capacity for adaptation to climate change, extreme weather, drought, flooding and other disasters and that progressively improve land and soil quality.
2.5 By 2020, maintain the genetic diversity of seeds, cultivated plants and farmed and domesticated animals and their related wild species, including through soundly managed and diversified seed and plant banks at the national, regional and international levels, and promote access to and fair and equitable sharing of benefits arising from the utilization of genetic resources and associated traditional knowledge, as internationally agreed.
2.a Increase investment, including through enhanced international cooperation, in rural infrastructure, agricultural research and extension services, technology development and plant and livestock gene banks in order to enhance agricultural productive capacity in developing countries, in particular least developed countries.
2.b Correct and prevent trade restrictions and distortions in world agricultural markets, including through the parallel elimination of all forms of agricultural export subsidies and all export measures with equivalent effect, in accordance with the mandate of the Doha Development Round.
2.c Adopt measures to ensure the proper functioning of food commodity markets and their derivatives and facilitate timely access to market information, including on food reserves, in order to help limit extreme food price volatility.

Goal 3. Ensure healthy lives and promote well-being for all at all ages

3.1 By 2030, reduce the global maternal mortality ratio to less than 70 per 100,000 live births.

3.2 By 2030, end preventable deaths of newborns and children under 5 years of age, with all countries aiming to reduce neonatal mortality to at least as low as 12 per 1,000 live births and under-5 mortality to at least as low as 25 per 1,000 live births.
3.3 By 2030, end the epidemics of AIDS, tuberculosis, malaria and neglected tropical diseases and combat hepatitis, water-borne diseases and other communicable diseases.
3.4 By 2030, reduce by one third premature mortality from non-communicable diseases through prevention and treatment and promote mental health and well-being.
3.5 Strengthen the prevention and treatment of substance abuse, including narcotic drug abuse and harmful use of alcohol.
3.6 By 2020, halve the number of global deaths and injuries from road traffic accidents.
3.7 By 2030, ensure universal access to sexual and reproductive health-care services, including for family planning, information and education, and the integration of reproductive health into national strategies and programmes.

3.8 Achieve universal health coverage, including financial risk protection, access to quality essential health-care services and access to safe, effective, quality and affordable essential medicines and vaccines for all.
3.9 By 2030, substantially reduce the number of deaths and illnesses from hazardous chemicals and air, water and soil pollution and contamination.
3.a Strengthen the implementation of the World Health Organization Framework Convention on Tobacco Control in all countries, as appropriate.
3.b Support the research and development of vaccines and medicines for the communicable and no communicable diseases that primarily affect developing countries, provide access to affordable essential medicines and vaccines, in accordance with the Doha Declaration on the TRIPS Agreement and Public Health, which affirms the right of developing countries to use to the full the provisions in the Agreement on Trade Related. Aspects of Intellectual Property Rights regarding flexibilities to protect public health, and, in particular, provide access to medicines for all.
3.c Substantially increase health financing and the recruitment, development, training and retention of the health workforce in developing countries, especially in least developed countries and small island developing States.
3.d Strengthen the capacity of all countries, in particular developing countries, for early warning, risk reduction and management of national and global health risks.

Goal 4. Ensure inclusive and equitable quality education and promote lifelong learning opportunities for all

4.1 By 2030, ensure that all girls and boys complete free, equitable and quality primary and secondary education leading to relevant and effective learning outcomes.
4.2 By 2030, ensure that all girls and boys have access to quality early childhood development, care and preprimary education so that they are ready for primary education.
4.3 By 2030, ensure equal access for all women and men to affordable and quality technical, vocational and tertiary education, including university.
4.4 By 2030, substantially increase the number of youth and adults who have relevant skills, including technical and vocational skills, for employment, decent jobs and entrepreneurship.
4.5 By 2030, eliminate gender disparities in education and ensure equal access to all levels of education and vocational training for the vulnerable, including persons with disabilities, indigenous peoples and children in vulnerable situations.
4.6 By 2030, ensure that all youth and a substantial proportion of adults, both men and women, achieve literacy and numeracy.
4.7 By 2030, ensure that all learners acquire the knowledge and skills needed to promote sustainable development, including, among others, through education for sustainable development and sustainable lifestyles, human rights, gender equality, promotion of a culture of peace and non-violence, global citizenship and appreciation of cultural diversity and of culture's contribution to sustainable development.

4.a Build and upgrade education facilities that are child, disability and gender sensitive and provide safe, nonviolent, inclusive and effective learning environments for all.
4.b By 2020, substantially expand globally the number of scholarships available to developing countries, in particular least developed countries, small island developing States and African countries, for enrolment in higher education, including vocational training and information and communications technology, technical, engineering and scientific programmes, in developed countries and other developing countries.
4.c By 2030, substantially increase the supply of qualified teachers, including through international cooperation for teacher training in developing countries, especially least developed countries and small island developing States.

Goal 5. Achieve gender equality and empower all women and girls

5.1 End all forms of discrimination against all women and girls everywhere.
5.2 Eliminate all forms of violence against all women and girls in the public and private spheres, including trafficking and sexual and other types of exploitation.
5.3 Eliminate all harmful practices, such as child, early and forced marriage and female genital mutilation.
5.4 Recognize and value unpaid care and domestic work through the provision of public services, infrastructure and social protection policies and the promotion of shared responsibility within the household and the family as nationally appropriate.
5.5 Ensure women's full and effective participation and equal opportunities for leadership at all levels of decision-making in political, economic and public life.
5.6 Ensure universal access to sexual and reproductive health and reproductive rights as agreed, in accordance with the Programme of Action of the International Conference on Population and Development and the Beijing Platform for Action and the outcome documents of their review conferences.
5.a Undertake reforms to give women equal rights to economic resources, as well as access to ownership and control over land and other forms of property, financial services, inheritance and natural resources, in accordance with national laws.
5.b Enhance the use of enabling technology, in particular information and communications technology, to promote the empowerment of women.
5.c Adopt and strengthen sound policies and enforceable legislation for the promotion of gender equality and the empowerment of all women and girls at all levels.

Goal 6. Ensure availability and sustainable management of water and sanitation for all

6.1 By 2030, achieve universal and equitable access to safe and affordable drinking water for all

6.2 By 2030, achieve access to adequate and equitable sanitation and hygiene for all and end open defecation, paying special attention to the needs of women and girls and those in vulnerable situations.

6.3 By 2030, improve water quality by reducing pollution, eliminating dumping and minimizing release of hazardous chemicals and materials, halving the proportion of untreated wastewater and substantially increasing recycling and safe reuse globally.

6.4 By 2030, substantially increase water-use efficiency across all sectors and ensure sustainable withdrawals and supply of freshwater to address water scarcity and substantially reduce the number of people suffering from water scarcity.

6.5 By 2030, implement integrated water resources management at all levels, including through transboundary cooperation as appropriate.

6.6 By 2020, protect and restore water-related ecosystems, including mountains, forests, wetlands, rivers, aquifers and lakes.

6.a By 2030, expand international cooperation and capacity-building support to developing countries in water- and sanitation-related activities and programmes, including water harvesting, desalination, water efficiency, wastewater treatment, recycling and reuse technologies.

6.b Support and strengthen the participation of local communities in improving water and sanitation management.

Goal 7. Ensure access to affordable, reliable, sustainable and modern energy for all

7.1 By 2030, ensure universal access to affordable, reliable and modern energy services.

7.2 By 2030, increase substantially the share of renewable energy in the global energy mix.

7.3 By 2030, double the global rate of improvement in energy efficiency.

7.a By 2030, enhance international cooperation to facilitate access to clean energy research and technology, including renewable energy, energy efficiency and advanced and cleaner fossil-fuel technology, and promote investment in energy infrastructure and clean energy technology.

7.b By 2030, expand infrastructure and upgrade technology for supplying modern and sustainable energy services for all in developing countries, in particular least developed countries, small island developing States, and land-locked developing countries, in accordance with their respective programmes of support.

Goal 8. Promote sustained, inclusive and sustainable economic growth, full and productive employment and decent work for all

8.1 Sustain per capita economic growth in accordance with national circumstances and, in particular, at least 7 per cent gross domestic product growth per annum in the least developed countries.

8.2 Achieve higher levels of economic productivity through diversification, technological upgrading and innovation, including through a focus on high-value added and labor-intensive sectors.

8.3 Promote development-oriented policies that support productive activities, decent job creation, entrepreneurship, creativity and innovation, and encourage the formalization and growth of micro-, small- and medium-sized enterprises, including through access to financial services.

8.4 Improve progressively. through 2030, global resource efficiency in consumption and production and endeavor to decouple economic growth from environmental degradation, in accordance with the 10-year framework of programmes on sustainable consumption and production, with developed countries taking the lead.

8.5 By 2030, achieve full and productive employment and decent work for all women and men, including for young people and persons with disabilities, and equal pay for work of equal value.

8.6 By 2020, substantially reduce the proportion of youth not in employment, education or training.

8.7 Take immediate and effective measures to eradicate forced labor, end modern slavery and human trafficking and secure the prohibition and elimination of the worst forms of child labor, including recruitment and use of child soldiers, and by 2025 end child labour in all its forms.

8.8 Protect labour rights and promote safe and secure working environments for all workers, including migrant workers, in particular women migrants, and those in precarious employment.

8.9 By 2030. devise and implement policies to promote sustainable tourism that creates jobs and promotes local culture' and products.

8.10 Strengthen the capacity of domestic financial institutions to encourage and expand access to banking, insurance and financial services for all.

8.a Increase Aid for Trade Support for developing· countries, in particular least developed countries, including through the Enhanced Integrated Framework for Trade-Related Technical Assistance to Least Developed Countries.

8.b By 2020, develop and operationalize a global strategy for youth employment and implement the Global Jobs Pact of the International Labour Organization.

Goal 9. Build resilient infrastructure, promote inclusive and sustainable industrialization and foster innovation

9.1 Develop quality, reliable. sustainable and resilient infrastructure, including regional and transborder infrastructure, to support economic development and human well-being. with a focus on affordable and equitable access for all.

9.2 Promote inclusive and sustainable industrialization and, by 2030, significantly raise industry's share of employment and gross domestic product, in line with national circumstances, and double its share in least developed countries.

9.3 Increase the access of small-scale industrial and other enterprises. in particular in developing countries, to financial services, including affordable credit, and their integration into value chains and markets.

9.4 By 2030, upgrade infrastructure and retrofit industries to make them sustainable, with increased resource-use efficiency and greater adoption of clean and environmentally sound technologies and industrial processes, with all countries taking action in accordance with their respective capabilities.

9.5 Enhance scientific research, upgrade the technological capabilities of industrial sectors in all countries, in particular developing countries, including. by 2030, encouraging innovation and substantially increasing the number of research and development workers per 1 million people and public and private research and development spending.

9.a Facilitate sustainable and resilient infrastructure development in developing countries through enhanced financial. technological and technical support to African countries, least developed countries, landlocked developing countries and small island developing States.

9.b Support domestic technology development, research and innovation in developing countries, including by ensuring a conducive policy environment for, inter alia, industrial diversification and value addition to commodities.

9.c Significantly increase access to information and communications technology.

Goal 10. Reduce inequality within and among countries

10.1 By 2030, progressively achieve and sustain income growth of the bottom 40 per cent often population at a rate higher than the national average.

10.2 By 2030, empower and promote the social, economic and political inclusion of all, irrespective of age, sex, disability, race, ethnicity, origin, religion or economic or other status.

10.3 Ensure equal opportunity and reduce inequalities of outcome, including by eliminating discriminatory laws, policies and practices and promoting appropriate legislation, policies and action in this regard.

10.4 Adopt policies, especially fiscal, wage and social protection policies, and progressively achieve greater equality.

10.5 Improve the regulation and monitoring of global financial markets and institutions and strengthen the implementation of such regulations.

10.6 Ensure enhanced representation and voice for developing countries in decision-making in global international economic and financial institutions in order to deliver more effective, credible, accountable and legitimate institutions.

10.7 Facilitate orderly, safe, regular and responsible migration and mobility of people, including through the implementation of planned and well-managed migration policies.

10.a Implement the principle of special and differential treatment for developing countries, in particular least developed countries, in accordance with World Trade Organization agreements.

10.b Encourage official development assistance and financial flows, including foreign direct investment, to States where the need is greatest, in particular least developed countries, African countries, small island developing States and landlocked developing countries, iIi accordance with their national plans and programmes.

10.c By 2030, reduce to less than 3 per cent the transaction costs of migrant remittances and eliminate remittance corridors with costs higher than 5 per cent.

Goal 11. Make cities and human settlements inclusive, safe, resilient and sustainable

11.1 By 2030, ensure access for all to adequate, safe and affordable housing and basic services and upgrade slums.

11.2 By 2030, provide access to safe, affordable, accessible and sustainable transport systems for all, improving road safety, notably by expanding public transport, with special attention to the needs of those in vulnerable situations, women, children, persons with disabilities and older persons.

11.3 By 2030, enhance inclusive and sustainable urbanization and capacity for participatory, integrated and sustainable human settlement planning and management in all countries.

11.4 Strengthen efforts to protect and safeguard the world's cultural and natural heritage.

11.5 By 2030, significantly reduce the number of deaths and the number of people affected and substantially decrease the direct economic losses relative to global gross domestic product caused by disasters, including water-related disasters, with a focus on protecting the poor and people in vulnerable situations.

11.6 By 2030, reduce the adverse per capita environmental impact of cities, including by paying special attention to air quality and municipal and other waste management.

11.7 By 2030, provide universal access to safe, inclusive and accessible, green and public spaces, in particular for women and children, older persons and persons with disabilities

11.a Support positive economic, social and environmental links between urban, peri urban and rural areas by strengthening national and regional development planning.

11.b By 2020, substantially increase the number of cities and human settlements adopting and implementing integrated policies and plans towards inclusion, resource efficiency, mitigation and adaptation to climate change, resilience to disasters, and develop and implement, in line with the Sendai Framework for Disaster Risk Reduction 2015-2030, holistic disaster risk management at all levels.

11.c Support least developed countries, including through financial and technical assistance, in building sustainable and resilient buildings utilizing local materials.

Goal 12. Ensure sustainable consumption and production patterns

12.1 Implement the 10-year framework of programmes on sustainable consumption and production, all countries taking action, with developed countries taking the lead, taking into account the development and capabilities of developing countries.

12.2 By 2030, achieve the sustainable management and efficient use of natural resources

12.3 By 2030, halve per capita global food waste at the retail and consumer levels and reduce food losses along production and supply chains, including post-harvest losses.

12.4 By 2020, achieve the environmentally sound management of chemicals and all wastes throughout their life cycle, in accordance with agreed international frameworks, and significantly reduce their release to air, water and soil in order to minimize their adverse impacts on human health and the environment.
12.5 By 2030, substantially reduce waste generation through prevention, reduction, recycling and reuse.
12.6 Encourage companies, especially large and transnational companies, to adopt sustainable practices and to integrate sustainability information into their reporting cycle.
12.7 Promote public procurement practices that are sustainable, in accordance with national policies and priorities.
12.8 By 2030, ensure that people everywhere have the relevant information and awareness for sustainable development and lifestyles in harmony with nature.
12.a Support developing countries to strengthen their scientific and technological capacity to move towards more sustainable patterns of consumption and production.
12.b Develop and implement tools to monitor sustainable development impacts for sustainable tourism that creates jobs and promotes local culture and products.
12.c Rationalize inefficient fossil-fuel subsidies that encourage wasteful consumption by removing market distortions, in accordance with national circumstances, including by restructuring taxation and phasing out those harmful subsidies, where they exist, to reflect their environmental impacts, taking fully into account the specific needs and conditions of developing countries and minimizing the possible adverse impacts on their development in a manner that protects the poor and the affected communities.

Goal 13. Take urgent action to combat climate change and its impacts*

13.1 Strengthen resilience and adaptive capacity to climate-related hazards and natural disasters in al1 countries.
13.2 Integrate climate change measures into national policies, strategies and planning.
13.3 Improve education, awareness-raising and human and institutional capacity on climate change mitigation, adaptation, impact reduction and early warning.
13.a Implement the commitment undertaken by developed-country parties to the United Nations Framework Convention on Climate Change to a goal of mobilizing jointly $100 billion annually by 2020 from all sources to address the needs of developing countries in the context of meaningful mitigation actions and transparency on implementation and fully operationalize the Green Climate Fund through its capitalization as soon as possible.
13.b Promote mechanisms for raising capacity for effective climate change-related planning and management in least developed countries and small island developing States, including focusing on women, youth and local and marginalized communities.
* Acknowledging that the United Nations Framework Convention on Climate Change is the primary international, intergovernmental forum for negotiating the global response to climate change.

Goal 14. Conserve and sustainably use the oceans, seas and marine resources for sustainable development

14.1 By 2025, prevent and significantly reduce marine pollution of all kinds, in particular from land-based activities, including marine debris and nutrient pollution.

14.2 By 2020, sustainably manage and protect marine and coastal ecosystems to avoid significant adverse impacts, including by strengthening their resilience, and take action for their restoration in order to achieve healthy and productive oceans.

14.3 Minimize and address the impacts of ocean acidification, including through enhanced scientific cooperation at all levels.

14.4 By 2020, effectively regulate harvesting and end overfishing, illegal, unreported and unregulated fishing and destructive fishing practices and implement science-based management plans, in order to restore fish stocks in the shortest time feasible, at least to levels that can produce maximum sustainable yield as determined by their biological characteristics.

14.5 By 2020, conserve at least 10 per cent of coastal and marine areas, consistent with national and international law and based on the best available scientific information.

14.6 By 2020, prohibit certain forms of fisheries subsidies which contribute to overcapacity and overfishing, eliminate subsidies that contribute to illegal, unreported and unregulated fishing and refrain from introducing new such subsidies, recognizing that appropriate and effective special and differential treatment for developing and least developed countries should be an integral part of the World Trade Organization fisheries subsidies negotiation.

14.7 By 2030, increase the economic benefits to Small Island developing States and least developed countries from the sustainable use of marine resources, including through sustainable management of fisheries, aquaculture and tourism.

14.a Increase scientific knowledge, develop research capacity and transfer marine technology, taking into account the Intergovernmental Oceanographic Commission Criteria and Guidelines on the Transfer of Marine Technology, in order to improve ocean health and to enhance the contribution of marine biodiversity to the development of developing countries, in pal1icular small island developing States and least developed countries.

14.b Provide access for small-scale artisanal fishers to marine resources and markets.

14.c Enhance the conservation and sustainable use of oceans and their resources by implementing international law as reflected in UNCLOS, which provides the legal framework for the conservation and sustainable use of oceans and their resources, as recalled in paragraph I5.8 of The Future We Want.

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

15.1 By 2020, ensure the conservation, restoration and sustainable use of terrestrial and inland freshwater ecosystems and their services, in particular forests, wetlands, mountains and drylands, in line with obligations under international agreements.

15.2 By 2020, promote the implementation of sustainable management of all types of forests, halt deforestation, restore degraded forests and substantiality increase afforestation and reforestation globally.

15.3 By 2030, combat desertification, restore degraded land and soil, including land affected by desertification, drought and floods, and strive to achieve a land degradation-neutral world.

15.4 By 2030, ensure the conservation of mountain ecosystems, including their biodiversity, in order to enhance their capacity to provide benefits that are essential for sustainable development.

15.5 Take urgent and significant action to reduce the degradation of natural habitats, halt the loss of biodiversity and, by 2020, protect and prevent the extinction of threatened species.

15.6 Promote fair and equitable sharing of the benefits arising from the utilization of genetic resources and promote appropriate access to such resources, as internationally agreed.

15.7 Take urgent action to end poaching and trafficking of protected species of flora and fauna and address both demand and supply of illegal wildlife products.

15.8 By 2020, introduce measures to prevent the introduction and significantly reduce the impact of invasive alien species on land and water ecosystems and control or eradicate the priority species.

15.9 By 2020, integrate ecosystem and biodiversity values into national and local planning, development processes, poverty reduction strategies and accounts.

15.a Mobilize and significantly increase financial resources from all sources to conserve and sustainably use biodiversity and ecosystems.

15.b Mobilize significant resources from all sources and at all levels to finance sustainable forest management and provide adequate incentives to developing countries to advance such management, including for conservation and reforestation.

15.c Enhance global support for efforts to combat poaching and trafficking of protected species, including by increasing the capacity of local communities to pursue sustainable livelihood opportunities.

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

16.1 Significantly reduce all forms of violence and related death rates everywhere.

16.2 End abuse, exploitation, trafficking and all forms of violence against and torture of children

16.3 Promote the rule of law at the national and international levels and ensure equal access to justice for all.

16.4 By 2030, significantly reduce illicit financial and arms flows, strengthen the recovery and return of stolen assets and combat all forms of organized crime.
16.5 Substantially reduce corruption and bribery in all their forms.
16.6 Develop effective, accountable and transparent institutions at all levels.
16.7 Ensure responsive, inclusive, pat1icipatory and representative decision-making at all levels
16.8 Broaden and strengthen the participation of developing countries in the institutions of global governance.
16.9 By 2030, provide legal identity for all, including birth registration.
16.10 Ensure public access to information and protect fundamental freedoms, in accordance with national legislation and international agreements.
16.a Strengthen relevant national institutions, including through international cooperation, for building capacity at all levels, in particular in developing countries, to prevent violence and combat terrorism and crime.
16.b Promote and enforce non-discriminatory laws and policies for sustainable development.

Goal 17. Strengthen the means of implementation and revitalize the global partnership for sustainable development

Finance

17.1 Strengthen domestic resource mobilization, including through international support to developing countries, to improve domestic capacity for tax and other revenue collection.
17.2 Developed countries to implement fully their official development assistance commitments, including the commitment by many developed countries to achieve the target of 0.7 per cent of ODA/GNI to developing countries and 0.15 to 0.20 per cent of ODA/GNI to least developed countries; ODA providers are encouraged to consider setting a target to provide at least 0.20 per cent of ODAIGNI to least developed countries.
17.3 Mobilize additional financial resources for developing countries from multiple sources.
17.4 Assist developing countries in attaining long-term debt sustainability through coordinated policies aimed at fostering debt financing, debt relief and debt restructuring, as appropriate, and address the external debt of highly indebted poor countries to reduce debt distress.
17.5 Adopt and implement investment promotion regimes for least developed countries.

Technology

17.6 Enhance North-South, South-South and triangular regional and international cooperation on and access to science, technology and innovation and enhance knowledge sharing on mutually agreed terms, including through improved coordination among existing mechanisms, in particular at the United Nations level, and through a global technology facilitation mechanism.
17.7 Promote the development, transfer, dissemination and diffusion of environmentally sound technologies to developing countries on favorable terms, including on concessional and preferential terms, as mutually agreed.

17.8 Fully operationalize the technology bank and science, technology and innovation capacity-building mechanism for least developed countries by 2017 and enhance the use of enabling technology, in particular information and communications technology.

Capacity-building

17.9 Enhance international support for implementing effective and targeted capacity-building in developing countries to support national plans to implement all the sustainable development goals, including through North-South, South-South and triangular cooperation.

Trade

17.10 Promote a universal, rules-based, open, non-discriminatory and equitable multilateral trading system under the World Trade Organization, including through the conclusion of negotiations under its Doha Development Agenda.
17.11 Significantly increase the exports of developing countries, in particular with a view to doubling the least developed countries' share of global exports by 2020.
17.12 Realize timely implementation of duty-free and quota-free market access on a lasting basis for all least developed countries, consistent with World Trade Organization decisions, including by ensuring that preferential rules of origin applicable to imports from least developed countries are transparent and simple, and contribute to facilitating market access.

Systemic issues

Policy and institutional coherence

17.13 Enhance global macroeconomic stability, including through policy coordination and policy coherence.
17.14 Enhance policy coherence for sustainable development.
17.15 Respect each country's policy space and leadership to establish and implement policies for poverty eradication and sustainable development.

Multi-stakeholder partnerships

17.16 Enhance the global partnership for sustainable development, complemented by multi-stakeholder partnerships that mobilize and share knowledge, expertise, technology and financial resources, to support the achievement of the sustainable development goals in all countries, in particular developing countries.
17.17 Encourage and promote effective public, public-private and civil society partnerships, building on the experience and resourcing strategies of partnerships.

Data, monitoring and accountability

17.18 By 2020, enhance capacity-building support to developing countries, including for least developed countries and small island developing States, to increase significantly the availability of high-quality, timely and reliable data disaggregated by income, gender, age, race, ethnicity, migratory status, disability, geographic location and other characteristics relevant in national contexts

17.19 By 2030, build on existing initiatives to develop measurements of progress on sustainable development that complement gross domestic product, and sup pod statistical capacity-building in developing countries

Annex 2 – Description of the fuzzy-AHP-TOPSIS method

This Annex 2 describes the Fuzzy combination of AHP method (proposed by Saaty (1977, 1991, 2008)) and the Technique to Evaluate the Performance of Alternatives by Similarity with the ideal Solution (TOPSIS), proposed by Hwang and Yoon, (1981). It is an integral part of the dissertation of Guilherme de Andrade Martins, entitled "AHP-TOPSIS Fuzzy Model for evaluation and selection of technologies for generating electricity from renewable sources" (Martins, 2017).

Description of Phase I - Fuzzy AHP

The steps of the first phase (fuzzy AHP) are described below to estimate the weights of the criteria and subcriteria. From the hierarchical decision structure of the multicriteria decision support method, the criteria and subcriteria, located at the level of the structure below the goal, are defined as factors considered to exert influence on the objective.

During this phase, with the definition of the criteria and subcriteria to evaluate the technological options, the judgments of the experts are required to define the importance of each criterion and subcriterion through the peer-to-peer comparison, according to the preference established between them. It is in this process that the comparison matrices are calculated, which in this model totaled six matrices: the first matrix contains the five criteria, and the others are composed by the subcriteria of each dimension evaluated (criteria).

Thus, a scale to assess the level of importance of each criterion and sub-criterion in paired comparisons is defined for the capture of the judgment of the experts. The importance of one attribute over the other are represented by triangular fuzzy numbers. These numbers are calculated according to the judgment of the experts by means of linguistic terms based on the Saaty scale in 9 levels, according to table A.1.

Table A.1 – SaatyScale

Level of importance	Definition	Explanation
1	Same importance	The two attirbutes contribute equally to the objective
3	Moderate importance of one over the other	The experience and the judgment slightly favor one attribute over another
5	Large or essential importance	The experience and the judgment strongly favor one attribute over another
7	Very large or demonstrated importance	One attribute is very strongly favored over the other; its domination of importance is demonstrated in practice.
9	Absolute Importance	The evidence favors one attribute over another with the highest degree of certainty
2,4,6,8	Intermediate values inbetween the adjacent values.	When you search for a compromise condition between the two settings

By definition, the triangular fuzzy number (1, 1, 1) is used when two attributes are considered equally important (level of importance equal to 1 in the Saaty scale). To represent the other levels of importance as a triangular fuzzy number (a1, a2, a3), all the judgments are counted in each paired comparison and simple arithmetic operations are performed to define the minimum points (a1), intermediate (a2) and maximum (a3).

With the experts' judgment, the matrices of paired comparison of criteria and subcriteria are assembled.

$$\begin{array}{c} \\ C_1 \\ C_2 \\ \vdots \\ C_n \end{array} \begin{array}{c} \begin{array}{ccccc} C_1 & & C_2 & & C_n \end{array} \\ \begin{bmatrix} (1,1,1) & (a_{1[1,2]}, a_{2[1,2]}, a_{3[1,2]}) & \cdots & (a_{1[1,n]}, a_{2[1,n]}, a_{3[1,n]}) \\ (1/a_{3[1,2]}, 1/a_{2[1,2]}, 1/a_{1[1,2]}) & (1,1,1) & & (a_{1[2,n]}, a_{2[2,n]}, a_{3[2,n]}) \\ \vdots & & \ddots & \vdots \\ (1/a_{3[1,n]}, 1/a_{2[1,n]}, 1/a_{1[1,n]}) & \cdots & & (1,1,1) \end{bmatrix} \end{array}$$

Figure A.1 - Generic comparison matrix

In order to exemplify, the figure A.1 presents an example of a comparison matrix in which the criterion C1 is preferable to criterion C2, assigning the fuzzy value to [1,2] = (a1, a2, a3) corresponding to the degree of importance of the first criterion on the second in the position (1,2) of the matrix, thus, in position (2,1) inserts the inverse of the fuzzy number. The inverse is calculated as follows:

$$a_{[2,1]} = (a_{[1,2]})^{-1} = (1/a_3, 1/a_2, 1/a_1) \quad (1)$$

The consistency analysis of the fuzzy paired comparison matrices by the consistency index (CI) can be performed with the classic AHP method, because when the comparison of the crisp matrix (fixed real values) A is consistent, it means that the fuzzy comparison matrix Ã is also consistent.

$$CR = \frac{CI}{RI} \quad (2)$$

$$CI = \frac{\lambda_{max} - n}{n - 1} \quad (3)$$

The consistency ratio (CR), equation 4, is used to estimate the consistency of paired comparisons, when RC ≤ 0.10 consistency is accepted, otherwise it is necessary to revise the comparison matrix. In equation 5, λmax is the largest eigenvalue and n the size of the matrix. The random index (RI) is a tabulated value of random consistency, shown in table A.2.

Table A.2 – Random Index (*RI*)

Tamanho $\boldsymbol{n}$	1	2	3	4	5	6	7	8
IR	0	0	0,52	0,89	1,11	1,25	1,35	1,40

To obtain the weights of the fuzzy AHP criteria and subcriteria the geometric mean method is used. Given the fuzzy comparison matrix Ã, the calculation of the weights occurs according to the following description:

$$\tilde{a}_i = (\prod_{j=1}^{3} \tilde{a}_{ij})^{\frac{1}{3}} = (\tilde{a}_{i1} \text{ x } \tilde{a}_{i2} \text{x } \tilde{a}_{i3})^{\frac{1}{3}} \quad (4)$$

$$\widetilde{W}_i = \frac{\tilde{a}_i}{\sum_{i=1}^{3} \tilde{a}_i} \quad (5)$$

$$\widetilde{W} = \{\widetilde{w}_1, \widetilde{w}_2, \cdots, \widetilde{w}_n\} \quad (6)$$

The vector $\widetilde{W}$ represents the result of the calculation of the weights, that is, it contains the weight of each criterion, finishing the *fuzzy* AHP step.

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Description of Phase II – *Fuzzy* TOPSIS

The Phase II steps of the model are described below, namely:

• constitution of the evaluation matrices, using the set of fuzzy linguistic terms;

• determination of the ideal fuzzy positive and negative solution (FPIS and FNIS) and distance definition for FPIS (D+) and FNIS (D-) and;

• determination of the relative proximity of the ideal value, resulting in final ordering.

After computing each note assigned by the respondents in evaluating the technologies, the values are converted to fuzzy triangular numbers. In this model, in addition to the notes attributed by the decision makers, some information come from data sources, according to subjective assessment.

From the linguistic terms and respective fuzzy values, the decision matrix D is constructed, according to the following example:

$$\widetilde{D} = \begin{matrix} A_1 \\ A_2 \\ \vdots \\ A_s \end{matrix} \begin{bmatrix} \tilde{x}_{11} & \tilde{x}_{12} & \dots & \tilde{x}_{1n} \\ \tilde{x}_{21} & \tilde{x}_{22} & \dots & \tilde{x}_{2n} \\ \vdots & \vdots & \vdots & \vdots \\ \tilde{x}_{s1} & \tilde{x}_{s2} & \dots & \tilde{x}_{sn} \end{bmatrix}, \; i = 1,2\ldots,s;\; j = 1,2,\ldots,n \qquad (7)$$

Where *Am* are the alternatives and x_{mn} are the values come from data base and/or attributed by decision makers.

In order to understand the fuzzy TOPSIS method it is necessary to present some fundamentals about algebraic operations. Let $\tilde{A}$ and $\tilde{B}$ be two fuzzy triangular numbers:

$$\tilde{A} + \tilde{B} = [a_{1_A}, a_{2_A}, a_{3_A}] + [a_{1_B}, a_{2_B}, a_{3_B}] = [a_{1_A} + a_{1_B}, a_{2_A} + a_{2_B}, a_{3_A} + a_{3_B}] \qquad (8)$$

$$\tilde{A} - \tilde{B} = [a_{1_A}, a_{2_A}, a_{3_A}] - [a_{1_B}, a_{2_B}, a_{3_B}] = [a_{1_A} - a_{1_B}, a_{2_A} - a_{2_B}, a_{3_A} - a_{3_B}] \qquad (9)$$

$$\tilde{A} * \tilde{B} = [a_{1_A}, a_{2_A}, a_{3_A}] * [a_{1_B}, a_{2_B}, a_{3_B}] = [a_{1_A} * a_{1_B}, a_{2_A} * a_{2_B}, a_{3_A} * a_{3_B}] \qquad (10)$$

$$\frac{\tilde{A}}{\tilde{B}} = \frac{[a_{1_A}, a_{2_A}, a_{3_A}]}{[a_{1_B}, a_{2_B}, a_{3_B}]} = \left[\frac{a_{1_A}}{a_{3_B}}, \frac{a_{2_A}}{a_{2_B}}, \frac{a_{3_A}}{a_{1_B}}\right] \qquad (11)$$

Using the evaluation matrix D, figure A.2, the algorithm of the fuzzy TOPSIS method is started.

$$\tilde{D} = \begin{matrix} \\ A_1 \\ \vdots \\ A_i \\ \vdots \\ A_n \end{matrix} \begin{matrix} \begin{matrix} C_1 & C_2 & .. & C_j & .. & C_m \end{matrix} \\ \begin{bmatrix} \tilde{x}_{11} & \tilde{x}_{12} & .. & \tilde{x}_{1j} & .. & \tilde{x}_{1m} \\ \vdots & \vdots & & \vdots & & \vdots \\ \tilde{x}_{i1} & \tilde{x}_{i2} & .. & \tilde{x}_{ij} & .. & \tilde{x}_{im} \\ \vdots & \vdots & & \vdots & & \vdots \\ \tilde{x}_{n1} & \tilde{x}_{n2} & .. & \tilde{x}_{nj} & .. & \tilde{x}_{nm} \end{bmatrix} \end{matrix}$$

Figure A.2 – Evaluation Matrix

The second step is to normalize the matrix $\tilde{D}$ using a linear transformation scale. The normalized matrix $\tilde{D}$, is obtained by equation 13.

$$\tilde{R} = [\tilde{r}_{ij}]_{mxn} \quad (12)$$

$$\tilde{r}_{ij} = \left(\frac{a_{1ij}}{a_{3j}^{+}}, \frac{a_{2ij}}{a_{3j}^{+}}, \frac{a_{3ij}}{a_{3j}^{+}}\right) \quad (13)$$

Considering $u_j^+ = \max_i u_{ij}$.

The third step is to obtain the normalized weighted matrix $\tilde{V}$ by multiplying the weights by the elements of the normalized matrix, equation 14.

$$\tilde{V} = [\tilde{v}_{ij}]_{mxn} \quad (14)$$

$$\tilde{v}_{ij} = \tilde{r}_{ij} * \tilde{w}_j \quad (15)$$

In the fourth step, the ideal fuzzy solution (FPIS, A^+) and negative (FNIS, A^-), are defined as equations 16 and 17.

$$A^+ = \{\tilde{v}_1^+, \tilde{v}_2^+, \cdots, \tilde{v}_m^+\} \quad (16)$$

$$A^- = \{\tilde{v}_1^-, \tilde{v}_2^-, \cdots, \tilde{v}_m^-\} \quad (17)$$

Where $\tilde{v}_1^+ = (1, 1, 1)$ e $\tilde{v}_1^- = (0, 0, 0)$.

The fifth step consists in defining the distance for FPIS (D +) and for FNIS (D-) with the equations 19 and 20.

$$D_i^+ = \sum_{j=1}^{n} d_v(\tilde{v}_{ij}, \tilde{v}_j^+) \quad (18)$$

$$D_i^- = \sum_{j=1}^{n} d_v(\tilde{v}_{ij}, \tilde{v}_j^-) \quad (19)$$

$$d(\tilde{X}, \tilde{Z}) = \sqrt{\frac{1}{3}\left[(a_{1_X} - a_{1_Z})^2 + (a_{2_X} - a_{2_Z})^2 + (a_{3_X} - a_{3_Z})^2\right]} \quad (20)$$

In the last step, the CCi approximation coefficients are calculated for each of the evaluated alternatives, according to equation 21.

$$CC_i = \frac{D_i^-}{D_i^+ + D_i^-} \quad (21)$$

Then, the final ordering of the alternatives evaluated with CCi values is defined, reaching the final objective.

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