

Article

A Systemic and Contextual Framework to Define a Country's 2030 Agenda from a Foresight Perspective

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Abstract: A fundamental issue in the implementation of the 2030 Agenda at the national level refers to the systemic analysis of interactions of global targets, considering the context-specific understanding of these interactions within a long-term vision. Another critical issue is how to apply and combine different approaches and tools to provide a consistent analysis for evidence-based decision-making on the Sustainable Development Goals (SDGs) and global targets. Consistent with both concerns, a systemic and contextual framework to prioritize SDG targets for a country's 2030 Agenda is proposed, by integrating fuzzy multicriteria decision-making methods, prospective structural analysis, and network theory tools. The applicability of the proposed framework could be demonstrated through a socio-technical experiment carried out during 2018 for the definition of the 2030 Agenda in Brazil. The experiment is especially designed to bring methodological insights to this decision-making process, and empirical results highlight the targets that will drive the Brazilian 2030 Agenda. Although the empirical results presented in this paper are exclusive to Brazil, we believe that the proposed framework can be replicated in other countries, especially those that are going to prioritize the global targets to be included in their respective Agendas.

Keywords: 2030 Agenda; sustainable development goals; multicriteria decision-making methods; prospective structural analysis; network theory; policy coherence

1. Introduction

The 2030 Agenda includes 17 Sustainable Development Goals (SDGs) and 169 global targets associated with them, all aimed at an integrated and transformative vision for a better and sustainable world. Building on the successful experience of the Millennium Development Goals (MDGs), the SDGs were defined on a participatory basis by Heads of State and Government and High Representatives of 193 countries in September 2015 [1].

Implementation of the SDG framework at the national level started in 2016, following the stages of a generic policy-planning toward global targets achievement by 2030. Since then, several guidelines, methodological assessments, conceptual models, and scientific works on this subject have been published [2–20].

Allen et al. (2016) [7] reviewed and compared strengths, weaknesses, and general utility of different models from the perspective of providing analytical support for national development planning for the SDGs. The authors highlighted a range of potential gaps in current modeling capabilities and concluded that the best methodological approach for prioritizing global targets is to apply a variety of complementary methods and to focus on a limited set of highly interrelated goals and targets. Moreover, foresighting and scenario analysis have been recommended strongly in several works addressed to the planning and implementation of the 2030 Agenda at the national level [7,15].

Many countries have begun implementation of the SDGs, and these efforts have been reported annually in Voluntary National Reviews (VNRs) submitted to the High-Level Political Forum (HLPF) on Sustainable Development—the United Nations central platform for follow-up and review of the 2030 Agenda [21]. A total of 66 countries submitted VNRs from 2016 to 2017 [19,21].

A recent work reviewed the experiences in implementing the SDGs in 26 countries and analyzed how guidelines and methodological approaches have been adopted by them to define their 2030 Agendas. The authors observed that progress had been recognized in initial planning stages, but key gaps remain in the next stages toward global targets achievement by 2030 [17]. The following are the critical gaps identified in this work: (i) assessing interlinkages, trade-offs and synergies between global targets (0% of countries had completed this step in 2017); (ii) policy evaluation and design (0% completed); (iii) prioritization of SDG targets and indicators based on a systematic approach of national circumstances to highlight targets with the greatest leverage potential and systemic impact (0% completed).

Although considerable research has been devoted to SDG implementation, gaps in current research, and policy analysis concerning how to think systemically about interactions across the SDGs within a long-term perspective, are evident. Another critical issue refers to unexplored combinations of complementary methodological approaches and tools to be provided [18–20].

Directly linked to both concerns, a research question arises—which global targets should be systemically included in a national 2030 Agenda, considering the main sustainability challenges of the country within a long-term vision? This paper aims to propose a systemic and contextual framework to prioritize global targets for defining a country's 2030 Agenda, by integrating fuzzy multicriteria decision-making methods, prospective structural analysis, and network theory tools, in an attempt to answer this question. The framework's applicability was demonstrated through a socio-technical experiment designed to bring methodological insights for the definition of the 2030 Agenda in Brazil.

Brazil was selected due to the authors' knowledge about the national socio-economic and political context, as well as data availability and an opportunity to invite relevant stakeholders, which enabled demonstrating the applicability of the proposed framework. Regarding the scenario of diversity that defines Brazil, the 2030 Agenda becomes an opportunity for improving public management toward the consolidation of policies that promote greater fairness and solidarity for the country [22].

According to Allen et al. [17], Brazil had implemented only the three initial steps of the 2030 Agenda implementation process, namely: (i) the establishment of institutional coordination mechanisms; (ii) multi-stakeholder consultation processes; and (iii) mapping of the SDGs and global targets against national strategies and plans. Concerning terms of adoption by the country of specific methodological approaches, clear gaps were evident concerning the application of most integrated and systems-based approaches to SDG implementation, as well as the use of scenarios, foresight, and backcasting methods. Considering the challenges for implementing the SDGs in Brazil, the conceptual framework proposed in this work can contribute with methodological insights for the remaining steps of the Brazilian 2030 Agenda implementation process, especially for the fourth step (i.e., prioritizing and adapting global targets and indicators at national and local levels).

This article is structured in six sections. Following this introduction, Section 2 details the adopted methodology. Section 3 proposes a systemic and contextual framework for prioritizing global targets to define a country's 2030 Agenda. Section 4 demonstrates the applicability of the proposed framework through a socio-technical experiment carried out in Brazil. The empirical results and policy implications are discussed in Section 5. Finally, the last section synthesizes the conclusions and suggestions for the replication of the proposed framework in countries that are going to prioritize the global targets to be included in their respective Agendas.

2. Methodology

The research methodology encompasses four phases and six stages, following a procedural model based on Wittstruck and Teuteberg (2012) [23] to provide an underlying structure and an approved

course of action for this research (Table 1). The phases are: (i) motivation; (ii) conceptualization and research gap identification; (iii) research design and development; and (iv) validation. Aligned with these phases, the stages refer to problem definition (first phase); state of scientific research on central themes and identification of research gaps and unsolved problems (second phase); definition of the research process; and development of the systemic and contextual framework for prioritizing global targets within a long-term vision (third phase); design and conduction of a socio-technical experiment in Brazil; and discussion of the empirical results and policy implications for the country (fourth phase).

Table 1. Research design.

Phase	Stage	Research Question	Paper Section
1. Motivation (Why?)	1.1 Problem definition	Why should we develop a systemic and contextual framework for prioritizing global targets within a long-term vision?	Section 1
2. Conceptualization and research gap identification (What?)	2.1. State of scientific research on central themes and identification of research gaps and unsolved problems	Which are the substantial gaps in the existing knowledge on the analysis of interactions of global targets? Which methods have been employed for prioritizing global targets at the national level?	
3. Research design and development (How?)	3.1 Definition of the research process	How can a systemic and contextual framework for prioritizing global targets within a long-term vision be developed and validated?	Section 2
	3.2 Development of the systemic and contextual framework	Which methods should be combined to overcome limitations of current research on the analysis of global targets interaction for better defining a 2030 Agenda at the national level? What are the benefits of integrating fuzzy multicriteria decision-making methods, prospective structural analysis, and social network theory to fill the research gaps pointed out in the first section?	Section 3
4. Validation (How effective is the proposed framework?)	4.1 Design and conduction of a socio-technical experiment in Brazil	Which criteria should be considered for prioritizing global targets associated with each SDG? Moreover, what weights should be assigned to the criteria considering the national context? Which global targets associated with each SDG should be prioritized for the prospective structural analysis according to Godet's methodology? What are the positive and negative interactions between prioritized global targets, using the Nilsson's scale, and considering context-specific understanding about target interactions? As a result of the prospective structural analysis, which global targets are classified as determinant, relay, and resultant ones? Using network analysis, what are the centrality metrics for the full network (all prioritized targets) and also for the determinant, relay, and resultant targets subnetworks?	Section 4
	4.2 Discussion of the empirical results and policy implications for the country	What are the main differentials of the proposed framework in relation to the current practices of prioritizing global targets at the national context? Could the results of the socio-technical experiment in Brazil demonstrate the effectiveness of the framework? Which are the main policy implications of this research?	Section 5

Source: Based on Wittstruck and Teuteberg [23].

During the first phase, the research problem was defined based on an exploratory review of scientific papers and guiding documents, covering the period from 2015 to 2019 [2–20]. The reasons why we should develop a systemic and contextual framework for prioritizing global targets within a

long-term vision were associated with two main concerns identified in this phase and discussed in the introductory section.

During the second phase of this work, a literature review and documentary analysis on the 2030 Agenda and SDG target implementation at a national level were conducted by accessing the main sources of peer-reviewed scientific articles, such as Scopus (<https://www.scopus.com>); Web of Science (<https://www.webofknowledge.com>); Science Direct (<https://www.sciencedirect.com>), and other sources, from the period from 2015 to 2019. Additionally, the Google Scholar (<https://scholar.google.com>) search was included to complement the first results. The following keywords were used and combined to achieve comprehensive search results: (i) 2030 Agenda; (ii) sustainable development goals (SDGs); (iii) systems analysis; (iv) network analysis; and (v) foresighting. This search strategy yielded a total of 60 documents that matched the combination of two or more keywords. Each selected document was checked for its relevance to the topics by reading the respective abstract and introduction. Furthermore, a backward search based on references cited in the selected documents also was carried out to complement the literature review. When all keywords were combined in one search string, the results indicated the research gaps, reinforcing the importance of developing a systemic and contextual framework for prioritizing SDG targets from a foresight perspective.

During the third phase, the research process was defined and detailed, and formal modeling was used to develop a systemic and contextual framework for prioritizing global targets to be included in a 2030 Agenda at the national level. The proposed framework combines fuzzy multicriteria decision-making methods [24–29], prospective structural analysis (PSA) [30], and network theory tools [31–34], as detailed in Section 3.1.

The fourth phase, comprising a socio-technical experiment, was designed and conducted to demonstrate the applicability of the proposed framework in the Brazilian context, with the participation of local experts engaged in sustainability issues and committed to the definition and implementation of the 2030 Agenda in Brazil. They are representatives of government institutions (Center for Strategic Technologies of the Northeast Region; and Brazilian Institute of Environment and Renewable Natural Resources); from academia (PUC-Rio, Federal University of Paraíba, and Federal University of Rio de Janeiro); and, also, from the industry (Petrobras; Enel Brazil; and São Francisco's Hydroelectric Company). Initially, the analysis was carried out at the level of the SDGs, following previous empirical works focusing on the cases of Sweden and some Arab and Asian countries [11,13,19]. Two targets per SDG were prioritized by the invited experts, i.e., 32 targets, excluding those targets concerning SDG 17, which are addressed as implementation issues. Prioritization of global targets by SDG was based on a fuzzy multicriteria approach and carried out through participatory meetings coordinated by the authors.

Subsequently, Prospective Structural Analysis (PSA) was employed for identifying direct and indirect interactions between the 32 global targets, conferring a methodological differential to the proposed framework in comparison to the previous models based on cross-impact analysis [11,13,19].

The main objective of integrating PSA in this framework was to classify the prioritized targets in clusters of key targets from a foresight perspective (i.e., considering indirect interactions until the 2030-time horizon). The use of influence-dependence charts allowed testing and comparison of the hierarchy of individual targets in terms of their direct and indirect influence on other targets.

Finally, the indirect influence-dependence chart could be reinterpreted in a full network graph visualization with the interlinkages between all prioritized targets for the Brazilian 2030 Agenda. We employed the Gephi software package and the Fruchterman and Reingold's algorithm [35]. Centrality metrics were used to analyze the structure of the full network (all target interlinkages), and also the three subnetworks, namely the determinant, relay, and resultant targets subnetworks. The regulator and autonomous targets were not relevant for visualization purposes.

3. Prioritizing Global Targets to Define a Country's 2030 Agenda: Proposal of a Systemic and Contextual Framework

We propose a systemic and contextual framework to define a country's 2030 Agenda based on fuzzy-multicriteria and foresight approaches. The development of this conceptual framework was in line with the following assumptions:

- The use of a fuzzy-analytic hierarchy process (f-AHP) and fuzzy-technique for order preference by similarity to ideal solution (f-TOPSIS) in the first two phases of the framework can absorb the subjectivity and the imprecision of expert judgments into the process of ranking alternative targets associated with each SDG;
- Taking a foresight view, prospective structural analysis (PSA) can describe the roles (current and future) played by the key global targets in all the stages of a generic policy-planning toward global targets achievement by 2030. The Matrix of Direct Influence (MDI) can reveal the interactions between global targets that occur in the short or medium term, while the Matrix of Indirect Influence (MII) integrates a sequence of impacts that would necessarily take more time, i.e., longer time-horizons (10–15 years);
- Compared to the influence-dependence chart of indirect interactions between global targets, the network analysis provides better visualization of the interactions between targets in two levels: (i) full network; and (ii) subnetworks related to the clusters identified by PSA, namely determinant, relay, and resultant targets. The ranking results of global targets against weighted centrality metrics can indicate the targets that play a central role in the full network, as well in subnetworks of determinant, relay, and resultant targets.

Shown in Figure 1, the conceptual framework comprises four phases, namely: (i) defining criteria for prioritizing global targets and weighting the criteria by a f-AHP method; (ii) prioritizing global targets related to SDGs with support of a f-TOPSIS method; (iii) PSA for identifying the role of key global targets from a foresight perspective; and (iv) network analysis for calculating weighted centrality metrics and visualizing the full network and subnetworks of global targets.

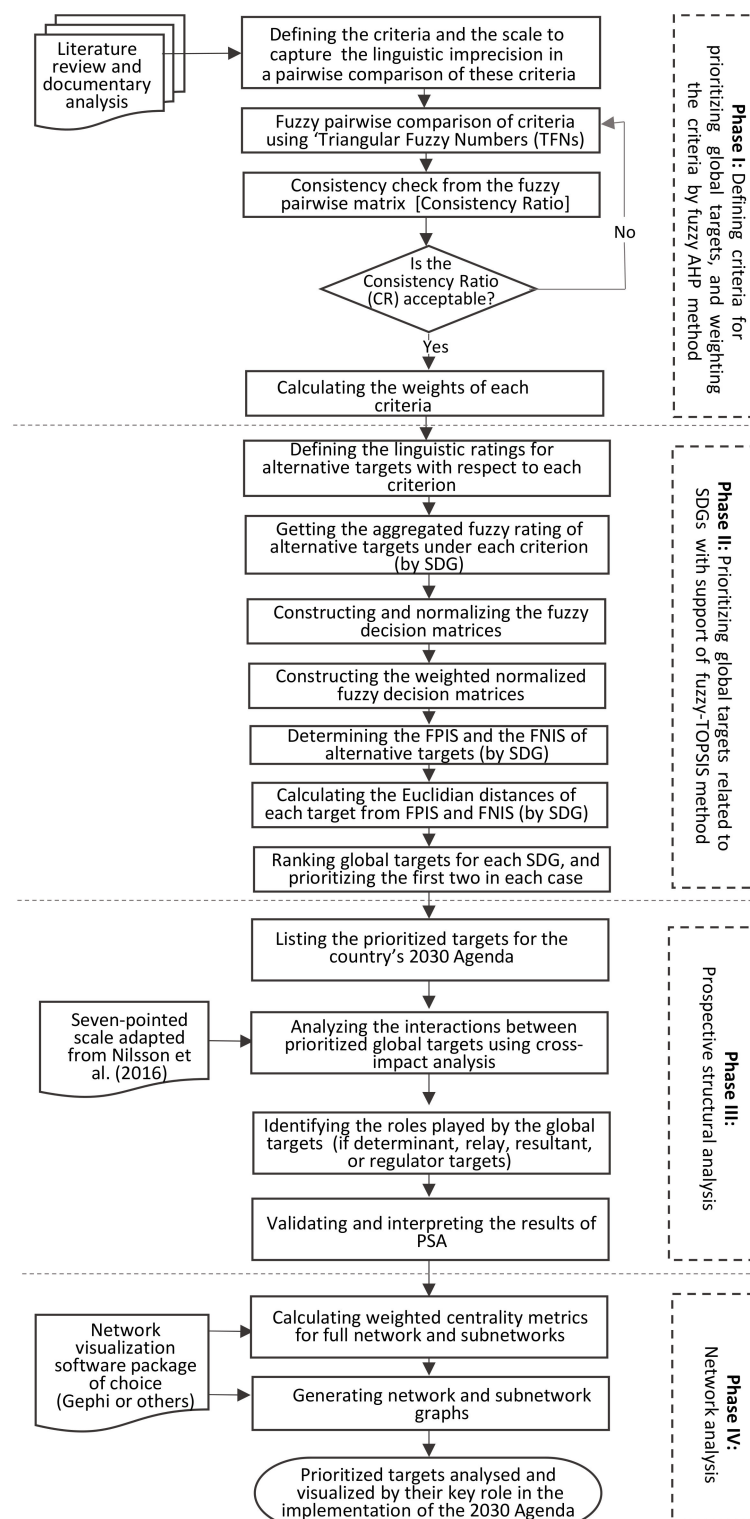


Figure 1. General view of the conceptual framework to define a country's 2030 Agenda.

The following subsections describe in detail each phase of the proposed framework.

3.1. Phase I: Defining Criteria for Prioritizing Global Targets and Weighting the Criteria by the Fuzzy-AHP Method

The first phase of the proposed framework is based on the fuzzy Analytical Hierarchy Process (fuzzy-AHP) approach that performs AHP under uncertainty and ambiguity to address imprecise

judgments of experts by using linguistic variables or fuzzy numbers. This method was chosen due to its ability to integrate qualitative and quantitative criteria and, also, to deal with expert judgments affected by uncertainty and imprecision [28].

Focusing on the problem of prioritizing SDG targets for a country's 2030 Agenda 2030, the fuzzy-AHP method can determine the relative importance of criteria defined for this purpose and encompass four steps: (i) defining the criteria and the scale to capture the linguistic imprecision in a pairwise comparison of these criteria; (ii) building the fuzzy pairwise comparison matrix showing the preference of one criterion over the other; (iii) consistency check the fuzzy pairwise comparison matrix, calculating the Consistency Ratio (CR); and (iv) calculating the weights of each criteria, if the CR is accepted.

The first step consists of defining the criteria for prioritizing global targets at the national level, and the scale to capture the linguistic imprecision in a pairwise comparison of these criteria.

The following criteria are suggested to be used in this phase:

- C1—Relevance of the target to overcome the country's sustainability challenges [4,10,11];
- C2—Policy coherence for the target implementation [20,36];
- C3—Criticality of the country indicators concerning the target, according to UN Dashboard.

Since the proposed framework considers the subjectivity, uncertainty, and ambiguity of experts' judgments, a fuzzy linguistic approach analog to the nine-pointed scale conceived by Saaty [26] should be used (Table 2).

Table 2. Linguistic terms and their respective fuzzy values.

Level of Importance According to Saaty [26]	Definition	Triangular Fuzzy Numbers (TFN)
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)

The second step aims to build the fuzzy pairwise comparison matrix showing the preference of one criterion over the other, based on the experts' judgmental values. Since the values are linguistic variables, TFNs are entered, according to the scale shown in Table 2.

During the third step, the consistency of the aggregate judgment matrix of all the pairwise comparisons is determined by its Consistency Ratio (CR). It is calculated by dividing the Consistency Index (CI) for the set of judgments by the index for the corresponding random matrix. Next, the CI can be calculated using the eigenvalue $\lambda_{\max}$, as follows:

$$CI = (\lambda_{\max} - n) / (n - 1), \text{ where } n \text{ is the matrix size.}$$

Saaty [26] suggests that the consistency of the matrix is acceptable only if $CR \leq 0.10$. When a matrix is inconsistent, then new pairwise comparison judgments are required. Once the consistency ratio is accepted, it is possible to calculate the weights of criteria, following the procedure described by Wang et al. (2008) [28].

3.2. Phase II: Prioritizing Global Targets Related to SDGs with Support of the Fuzzy-TOPSIS Method

Analogously to the first phase, a fuzzy methodological approach was chosen to absorb the subjectivity and the imprecision of human judgments into the process of prioritizing alternatives. So, the second phase of the proposed framework is supported by the fuzzy Technique for Order Preference by Similarity to Ideal Solution (fuzzy-TOPSIS), as described by Chen [29].

The fuzzy-TOPSIS method is conducted in seven steps, as follows: (i) defining the linguistic ratings for alternative targets with respect to each criterion; (ii) getting the aggregated fuzzy rating of alternative targets under each criterion (by SDG); (iii) constructing and normalizing the fuzzy decision matrices; (iv) constructing the weighted normalized fuzzy decision matrices; (v) determining the Fuzzy Positive Ideal Solution (FPIS) and the Fuzzy Negative Ideal Solution (FNIS); (vi) calculating the Euclidian distances of each alternative target from FPIS and FNIS; and (vii) ranking global targets for each SDG, and prioritizing the first two in each case.

The adopted scale to build the decision matrices is presented in Table 3. The crisp scale is the one that the experts will use, during the second step, to evaluate the alternatives in the light of the established criteria.

Table 3. Defining the crisp and fuzzy scales to each criterion.

Criterion	Attribute	Associated Crisp Scale	Associated Fuzzy Scale
C1—Relevance of the target to overcome the country's sustainability 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, according to UN Dashboard	Red	4	(3;4;4)
	Orange	3	(2;3;4)
	Yellow	2	(1;2;3)
	Green	1	(1;1;2)

Regarding the criterion C1, a target is considered very highly relevant when it reflects the country reality according to its geography, biomes, social factors, level of development, and culture, among other characteristics. To define the degree of relevance of each target to overcome the country's sustainability challenges, a survey is suggested using as many experts as possible.

The evaluation of the criterion C2 requires content analyses about current government programs in the country. A high alignment indicates that government programs have a direct contribution to the target achievement.

Finally, the criterion C3 refers to the results delivered by the UN Dashboard indicators concerning the country's stage in relation to each SDG. Since not all indicators have been developed yet, some targets cannot be monitored and evaluated. Then, if a target still does not have an associated indicator, it should be evaluated according to the color of the SDG associated with the target.

Following all expert judgments, the values must be fuzzified according to the corresponding fuzzy scale and organized in fuzzy decision matrices (one for each SDG). The fuzzy decision matrices should be normalized, using the linear scale transformation to transform the various criteria scales into a comparable scale. Subsequently, the weighted normalized fuzzy decision matrices are constructed in the fourth step. Then, the Fuzzy Positive Ideal Solution (FPIS) and the Fuzzy Negative Ideal Solution (FNIS) can be calculated in the fifth step. Afterward, the Euclidian Distance of each alternative target from FPIS and FNIS is calculated in the sixth step. Finally, in the seventh step, it is possible to calculate

the closeness coefficient of each alternative target, and the ranking order of all alternative targets can be determined for each SDG.

This procedure should be done for each one of the 16 SDGs. All the formulas and parameters used in this procedure can be found in Chen (2000) [29].

3.3. Phase III: Prospective Structural Analysis (PSA) for Identifying The Role of Key Global Targets from a Foresight Perspective

Prospective structural analysis (PSA) is the usual method of choice for describing a system and eliciting the roles (current and future) played by the key variables in the evolution of a system over long-term horizons [30,37]. This section aims to go deeper into classifying the prioritized global targets according to their degree of influence/dependence using PSA.

Here, global targets are the variables to be analyzed considering a long-term time horizon (2030), and the system refers to the implementation of the SDG framework at the national level, following the stages of a generic policy-planning toward global targets achievement by 2030.

To identify the role of key global targets from a foresight perspective, PSA should be conducted through participatory meetings in four steps, as follows: (i) listing the prioritized targets for the country's 2030 Agenda; (ii) analyzing the interactions between prioritized global targets, using cross-impact analysis and a seven-point scale adapted from Nilsson et al. [5,6,18]; (iii) identifying the roles played by the global targets (if determinant, relay, resultant, or regulator targets); and (iv) validating and interpreting the results of PSA.

The first step consists of listing the prioritized targets for the 2030 Agenda at the national level. We suggest that the analysis should be limited to two targets per SDG, those ranked in higher positions by the hybrid fuzzy-AHP-TOPSIS method.

During the second step, a cross-impact analysis is performed by experts to assess the influences between the prioritized global targets. Initially, a square cross-impact matrix ($n \times n$) is framed, in which each target of the row should be crossed to all targets on the columns and assessed according to this question: if progress is made on target i (rows), how does this influence progress on target j (columns)? The answers should be done according to the seven-point scale adapted from Nilsson et al. [5,6,18] for analyzing global targets interactions (Table 4). The sign (positive/negative) of each influence should be introduced in the matrix, as reported in previous works concerning 2030 Agenda [11,19].

During the participatory meetings, it is strongly recommended that experts objectively perceive the real direct influences, and differentiate the direction of the influence, i.e., which of the two focused variables influences the other. The participants should agree on the final degree of influence of an individual target on the other targets. The results of this second step are represented in a Matrix of Direct Influence (MDI), in which the row-sum indicates the influence exerted from a target on all others, and the column-sum shows how dependent each target is on all the other targets [30].

The third step aims to identify the roles played by the targets (if determinant, relay, resultant, or regulator targets). During this PSA step, Microsoft® Office Excel (Microsoft Corporation, Washington, WA, USA) can be used to calculate the indirect influence and dependence of each target. MDI is then raised to the second, third, ... n th power until the overall ranking of the variables' influence and dependence remains constant.

The resultant stable matrix is called a Matrix of Indirect Influence (MII) and determines the indirect influences between all targets over one, two ... $n - 1$ targets.

According to Godet [30], the MDI can express the interactions between targets that occur in the short or medium term, whereas the MII integrates a sequence of impacts that would necessarily take more time, i.e., longer time-horizons (10–15 years). Indeed, for the purpose of defining a country's 2030 Agenda (time-horizon higher than ten years), PSA offers more resources than the cross-impact analysis used in previous works [11,19].

Table 4. Seven-point scale for analyzing global targets interactions.

Interaction	Description
Indivisible (+3)	The strongest form of positive interaction in which one global target is linked inextricably to the achievement of another.
Reinforcing (+2)	One global target directly creates conditions that lead to the achievement of another objective.
Enabling (+1)	The pursuit of one global target enables the achievement of another objective.
Consistent (0)	A neutral relationship where one global target 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 global target sets a condition or a constraint on the achievement of another.
Counteracting (−2)	The pursuit of one global target counteracts another target
Cancelling (−3)	The most negative interaction is where progress in one global target makes it impossible to reach another target and possibly leads to a deteriorating state of the second.

Source: Adapted from Nilsson et al. [5,6,18].

The results of both MDI and MII can be plotted respectively in direct and indirect influence/dependence charts. These charts show the current and future perceptions of the implementation of the SDG framework at the national level, following the stages of a generic policy-planning toward global targets achievement by 2030 (Figure 2).

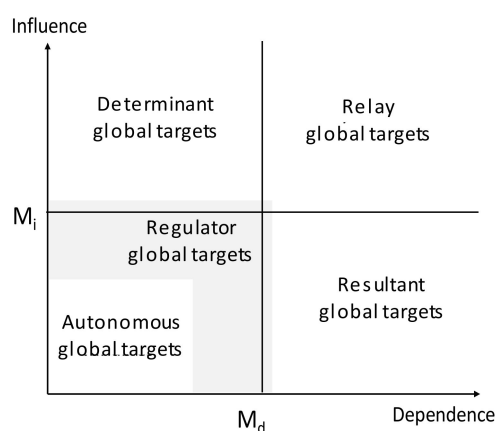


Figure 2. Classification of global targets according to their influence and dependence: a generic influence-dependence chart. **Source:** Adapted from Godet [30] (p. 99). **Note:** M_i and M_d represent the medium points, considering the average of the sum of the highest value and the lowest value, to both the influence and dependence axes.

The position of each global target in an influence-dependence chart indicates the role played by them in the implementation of the 2030 Agenda. As proposed by Godet [30] these functions are: (i) determinant targets; (ii) relay targets; (iii) resultant targets; (iv) regulator targets or middle-cluster; and (v) autonomous targets.

Focusing on the SDG framework, determinant targets are the most influential ones and play a role as driving forces in relation to the other targets. They can control the implementation of the country's 2030 Agenda as a whole. The targets that occupy these positions are indicated to be the first ones to be implemented. Making progress on these will bring progress to other targets (relay and resultant ones). Relay targets are unstable by nature because any action on these targets will have consequences on

resultant ones [30]. They could mean significant progress or boomerang effects on the 2030 Agenda as a whole.

Resultant targets are the most influenced (dependent) ones. They are susceptible to changes in trajectories of determinant or relay targets. It is worth investing in 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. Regulator targets have moderate dependence and influence on the 2030 Agenda and act as levers. Autonomous targets have a low potential to generate changes. Suggested by Godet [30], in general, they are excluded because they are not expected to influence the future of the system.

Finally, the fourth step of PSA consists of one or more meetings with a broader number of participants for interpreting and validating the results of PSA presented by the group of experts involved in this prospective analysis. During these events, the participants discuss the roles played by key variables, visualized in influence-dependence charts, and give feedback to the former group of experts.

3.4. Phase IV: Network Analysis for Calculating Weighted Centrality Metrics and Visualizing the Full Network and Subnetworks of Global Targets

Based on network analysis [31–34], all indirect interactions identified by PSA can be visualized in network graphs, as follows: (i) a full network graph encompasses all indirect interactions of the prioritized global targets at the national context; and (ii) three subnetwork graphs representing the clusters of determinant, relay, and resultant targets. To complete this task, any freely available network visualization software package can be used, such as Gephi (<https://gephi.org>); Pajek (<http://mrvar.fdv.uni-lj.si/pajek/>); Netdraw (<https://sites.google.com/site/netdrawsoftware/home>); and Kumu (<https://kumu.io>).

When using the network graphs, the elements are represented by vertices or nodes and their connections by edges. Considering the 2030 Agenda perspective, each global target is a node, and the edges are the interlinkages between the targets. The network graphs can be generated by one of the mentioned network visualization software packages. Statistical measures available in these packages can be selected for the intended network analysis.

Centrality is the statistical measure of the intensity of the connections of a given cluster, and it can be calculated by the average value of the connections that exist between the targets. Centrality aims to find the most important nodes in a network [31–34], in other words. The metrics for measuring centrality recommended for this phase are:

- Weighted degree centrality—the number of a node’s interactions weighted by the strength of each edge. A high value indicates the central role of a target in connecting widely with others;
- Weighted in-degree centrality—a node (target) receiving influences from other targets with a positive value for reinforcing effects and a negative value for conflicting effects, weighted by the strength of each edge;
- Weighted out-degree centrality—a target is exerting influences on other targets with a positive value for reinforcing effects and negative value for conflicting effects, weighted by the strength of each edge.

4. Empirical Validation of the Systemic and Conceptual Framework in the Brazilian Context

To demonstrate the effectiveness of the proposed framework in the Brazilian context, we developed a socio-technical experiment carried out by eight local representatives of academia, government, and industry, committed to the planning and implementation of the Brazilian 2030 Agenda. The experiment was coordinated by the authors to answer the following question: “How can fuzzy multicriteria decision-making methods, prospective structural analysis, and network theory tools contribute to defining better which global targets should be included in the Brazilian 2030 Agenda from a foresight perspective?”.

4.1. Phase I: Defining Criteria for Prioritizing Global Targets and Weighting the Criteria by the Fuzzy-AHP Method

Tables 5 and 6 show the step-by-step results of criteria weighting by pairwise comparison using the fuzzy-AHP method. The final criteria weights (Table 7) will be used in the fuzzy-TOPSIS phase to prioritize global targets associated with each SDG.

Table 5. Criteria weighting by fuzzy-AHP pairwise comparison.

	C1	C2	C3
C1	[1,1,1]	[2,3,4]	[1,2,3]
C2	[1/4, 1/3, 1/2]	[1,1,1]	[1/4,1/3, 1/2]
C3	[1/3, 1/2, 1/1]	[2,3,4]	[1,1,1]

Legend: C1—Relevance of the target to overcome the country's sustainability challenges; C2—Policy coherence for the target implementation; C3—Criticality of the country indicators concerning the target.

Table 6. Final criteria weighting by fuzzy-AHP method.

	l	m	u
C1	0.280	0.528	0.905
C2	0.088	0.140	0.249
C3	0.194	0.332	0.627

Legend: l—lower value; m—medium value; u—upper value.

Table 7. Crisp decision matrix for prioritizing the global targets under SDG2 in the Brazilian context.

Targets Under SDG2		Criteria		
		C1	C2	C3
2.1	End hunger and ensure access by all people to safe, nutritious and sufficient food all year round	3	2	1
2.2	Child malnutrition	3	1	1
2.3	Agricultural productivity/small-scale food producers	2	4	3
2.4	Food production/agriculture	4	3	3
2.5	Safeguard and share the genetic diversity [crops and livestock]	1	2	3

Legend: C1—Relevance of the target to overcome the country's sustainability challenges; C2—Policy coherence for the target implementation; C3—Criticality of the country indicators concerning the target, according to UN Dashboard.

To illustrate, if an expert judges that criterion 1 (C1) is moderately more important than criterion 2 (C2), it means that on fuzzy triangular scale criterion 1 relative to criterion 2 will be (2,3,4), expressed by a Triangular Fuzzy Number (TFN) rather than the crisp number 3. The paired comparison of C2 with C1, according to the triangular fuzzy scale, should be (1/4, 1/3, 1/2).

Observing Table 6, the most important decision criteria were “Relevance of the target to overcome the country's sustainability challenges” (C1) and “Criticality of the country indicators concerning the target, according to UN Dashboard” (C3), followed by the criteria “Policy coherence for the target implementation” (C2).

These results were submitted to the qualitative evaluation of the invited experts and were considered satisfactory. Thus, the lower, medium, and upper values presented in Table 6 were adopted in the subsequent phase supported by the fuzzy-TOPSIS method, as illustrated in Chen [29] (p. 8).

4.2. Phase II: Prioritizing Global Targets Related to SDGs with Support of the Fuzzy-TOPSIS Method

Section 3 mentions the prioritization of subordinate targets to each one of the 16 SDGs should be done with the support of the fuzzy-TOPSIS method. However, due to limitations of space, only the results related to SDG2 are presented here to illustrate a concrete case of this phase.

Table 7 depicts the values that were assigned by experts to get the aggregated fuzzy rating of the global targets under SDG2, using the scale defined in Table 3.

All the assigned crisp values were converted into triangular fuzzy numbers (TFN) for constructing the fuzzy decision matrix related to the global targets under SDG2, as depicted in Table 8.

Table 8. Fuzzy decision matrix (D) for prioritizing the global targets under SDG2 in the Brazilian context.

D	Global Targets Under SDG2														
	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	4	2	3	4	1	2	3	3	4	4	1	1	2
C2	1	2	3	1	1	2	3	4	4	2	3	4	1	2	3
C3	1	1	2	1	1	2	2	3	4	2	3	4	2	3	4

Legend: l—lower value; m—medium value; u—upper value.

Subsequently, the weighted fuzzy decision matrix (DxW) was built for this SDG, as shown in Table 9.

Table 9. Weighted fuzzy decision matrix (DxW) for prioritizing global targets under SDG 2.

DxW	Global Targets Under SDG2														
	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	0.559	1.584	3.619	0.559	1.584	3.619	0.280	1.056	2.714	0.839	2.111	3.619	0.280	0.528	1.810
C2	0.088	0.279	0.747	0.088	0.140	0.498	0.264	0.559	0.996	0.176	0.419	0.996	0.088	0.279	0.747
C3	0.194	0.333	1.255	0.194	0.333	1.255	0.388	0.998	2.509	0.388	0.998	2.509	0.388	0.998	2.509

Legend: l—lower value; m—medium value; u—upper value.

The next step was to construct the weighted normalized fuzzy decision matrix (IDxWI), as shown in Table 10.

Table 10. Weighted normalized fuzzy decision matrix for prioritizing global targets under SDG 2.

IDxWI	Global Targets Under SDG2														
	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	0.154	0.438	1.000	0.154	0.438	1.000	0.077	0.292	0.750	0.232	0.583	1.000	0.077	0.146	0.500
C2	0.088	0.280	0.750	0.088	0.140	0.500	0.265	0.561	1.000	0.177	0.421	1.000	0.088	0.280	0.750
C3	0.077	0.133	0.500	0.077	0.133	0.500	0.154	0.398	1.000	0.154	0.398	1.000	0.154	0.398	1.000

Legend: l—lower value; m—medium value; u—upper value.

Then, the Fuzzy Positive Ideal Solution (FPIS) and the Fuzzy Negative Ideal Solution (FNIS) were determined for each global target under SDG2 (Tables 11 and 12).

Table 11. Fuzzy Positive Ideal Solution (FPIS) determined for the global targets under SDG2.

A+	d(A1, O+)	d(A2, O+)	d(A3, O+)	d(A4, O+)	d(A5, O+)
C1	0.5863	0.5863	0.6869	0.5046	0.7813
C2	0.6859	0.7789	0.4942	0.5811	0.6859
C3	0.7861	0.7861	0.5994	0.5994	0.5994

Table 12. Fuzzy Negative Ideal Solution (FNIS) determined for the global targets under SDG2.

A-	d(A1, O−)	d(A2, O−)	d(A3, O−)	d(A4, O−)	d(A5, O−)
C1	0.6365	0.6365	0.4667	0.6817	0.3040
C2	0.4651	0.3041	0.6795	0.6346	0.4651
C3	0.3020	0.3020	0.6277	0.6277	0.6277

Following, we calculated the Euclidian Distances (D+ and D−) of each target from FPIS and FNIS, and their Closeness Coefficients (CCi). The final ranking of the alternative targets could be defined for SDG 2, being target 2.4 (“Sustainable food production/agriculture”) in the first position, followed by target 2.3 (“Agricultural productivity/small-scale food”), as shown in Table 13.

Table 13. Euclidian Distances, Closeness Coefficients, and the final ranking of the global targets under SDG2.

Global Targets	Euclidian Distances and Closeness Coefficient of Each Target from FPIS and FNIS			Final Ranking	
	D+	D−	CCi		
2.1	2.0583	1.4035	0.4054	2.4	0.5357
2.2	2.1514	1.2426	0.3661	2.3	0.4991
2.3	1.7805	1.7739	0.4991	2.1	0.4054
2.4	1.6851	1.9440	0.5357	2.5	0.4033
2.5	2.0665	1.3968	0.4033	2.2	0.3661

The whole procedure of this phase was carried out for the targets of each SDG, pooling the expert judgments to get the aggregated fuzzy rating of all global targets under each SDG, and prioritizing the first two in each case. The final result was a list of 32 global targets, as shown in Table 14.

Table 14. Global targets prioritized for the Brazilian 2030 Agenda.

Target	Short Description
1.2	Reduction of poverty
1.3	Social protection systems
2.3	Agricultural productivity/small-scale food producers
2.4	Sustainable food production/agriculture
3.2	Preventable deaths of newborns/under-5 mortality
3.8	Health coverage
4.1	Primary and secondary education
4.7	Knowledge and skills to promote sustainable development
5.2	Elimination of violence against all women and girls
5.5	Women’s participation and equal opportunities for leadership
6.1	Drinking water for all
6.3	Improvement of water quality
7.1	Universal access to energy
7.2	Renewable energy
8.3	Decent work, innovation, and economic growth
8.4	Resource efficiency
9.4	Upgraded infrastructure

Table 14. Cont.

Target	Short Description
9.5	Research and development
10.1	Economic equality
10.6	Enhanced representation and voice for developing countries in decision-making in global international economic and financial institutions
11.1	Affordable housing
11.6	Reduction of the environmental impact of cities
12.3	Reduction of food losses
12.8	Information and awareness for sustainable development
13.2	Climate change policy/planning
13.3	Education and institutional capacity on climate change
14.1	Reduction of marine pollution
14.2	Healthy and productive oceans
15.1	Terrestrial and inland freshwater ecosystems and their services
15.3	Land degradation-neutral country
16.3	Equal access to justice for all
16.5	Reduction of corruption and bribery

Source: Based on United Nations [1].

4.3. Phase III: Prospective Structural Analysis (PSA) for Identifying the Role of Key Global Targets from a Foresight Perspective

The procedure of prospective structural analysis (PSA) described in Section 3 was applied to the 32 global targets prioritized in Phase II (see Table 14).

To assess the influences between the prioritized global targets, a square cross-impact matrix (32×32) was built. The invited experts fulfilled this matrix according to the seven-point scale defined in Table 4.

Figure 3 shows the Matrix of Direct Influence (MDI), in which the row-sum indicates the general influence exerted from a target on all others, and the column-sum shows how dependent each target is on all the other targets.

	1.2	1.3	2.3	2.4	3.2	3.8	4.1	4.7	5.2	5.5	6.1	6.3	7.1	7.2	7.8	8.3	8.4	9.4	9.5	10.1	10.6	11.1	11.6	12.3	12.8	13.2	13.3	14.1	14.2	15.1	15.3	16.3	16.5	INFL	
1.2	0	1	1	0	2	1	1	1	3	1	1	2	1	0	1	1	0	0	3	1	2	2	1	1	0	1	1	0	1	1	1	1	0	32	
1.3	2	0	2	2	2	3	1	0	3	0	3	1	2	0	1	1	0	0	3	1	3	1	0	0	0	0	0	0	0	0	1	1	0	33	
2.3	2	2	0	1	0	0	0	0	0	0	-1	-1	1	1	0	0	0	0	3	1	0	0	0	1	0	0	0	0	0	-1	2	1	0	12	
2.4	2	1	1	0	1	0	0	0	0	0	-1	2	1	1	0	1	0	0	0	1	0	0	3	0	0	0	0	3	2	2	3	1	0	24	
3.2	0	0	0	0	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	0	0	0	1		
3.8	1	1	0	0	3	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	7	
4.1	3	1	0	0	1	1	0	2	3	2	0	0	0	0	3	0	1	1	3	1	0	1	0	2	0	2	0	0	0	0	0	1	0	28	
4.7	3	0	1	1	0	2	1	0	3	2	0	1	0	1	1	2	1	1	2	1	0	2	3	3	0	2	1	1	1	1	1	0	3	40	
5.2	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	2	2	
5.5	0	0	0	0	0	2	2	1	2	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	8	
6.1	1	2	3	3	1	3	1	1	0	0	0	1	0	1	0	2	1	0	0	0	3	2	0	0	0	0	0	0	0	0	2	0	0	27	
6.3	0	0	3	3	0	2	0	1	0	0	2	0	0	1	0	1	1	0	0	0	1	1	2	0	0	0	0	1	1	2	0	0	0	22	
7.1	2	1	3	1	0	1	1	1	1	0	0	1	0	1	1	1	0	0	2	1	1	0	0	1	0	1	0	0	0	0	0	1	0	22	
7.2	1	0	2	1	0	1	0	1	0	0	1	1	1	0	1	1	2	2	2	0	1	2	0	1	3	1	0	0	1	0	0	0	1	27	
8.3	3	1	2	1	0	1	2	1	0	0	1	2	1	1	0	1	1	0	3	2	2	1	0	0	0	0	0	1	1	2	1	1	0	32	
8.4	0	0	1	2	0	0	1	1	0	0	1	2	1	1	1	0	3	2	0	0	2	2	3	1	2	1	2	2	2	2	1	1	0	35	
9.4	0	0	0	0	0	1	0	0	0	0	1	2	1	2	1	3	0	2	0	1	2	1	3	2	1	1	2	1	2	0	1	0	30		
9.5	1	1	1	1	0	2	1	1	1	0	1	1	1	1	1	2	2	0	1	1	1	1	2	1	3	2	1	1	1	1	2	1	0	36	
10.1	3	1	1	0	2	1	0	0	2	1	0	0	0	0	2	0	0	0	0	2	2	-1	0	0	0	0	0	0	0	0	0	1	0	17	
10.6	2	2	2	1	1	2	2	2	2	2	1	1	2	2	1	1	2	2	2	0	2	1	0	2	2	2	2	2	2	2	2	2	2	53	
11.1	2	1	0	0	1	1	0	0	2	0	2	1	2	0	0	0	0	0	0	1	0	1	1	0	0	0	0	0	0	0	0	1	0	16	
11.6	0	0	0	0	0	0	0	0	0	0	0	1	0	2	0	0	0	0	0	0	1	0	2	0	1	1	0	0	0	0	0	0	0	8	
12.3	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	3	1	1	0	0	0	2	0	0	0	0	0	0	0	0	0	0	0	8	
12.8	0	0	2	2	0	1	2	2	1	0	1	2	1	2	0	2	3	1	1	1	1	2	3	0	1	3	2	2	2	2	2	2	1	45	
13.2	0	0	1	1	0	0	0	0	0	0	1	2	1	2	0	3	3	1	0	1	0	2	0	1	0	2	2	2	2	2	3	0	0	30	
13.3	0	0	1	1	0	0	1	1	0	0	1	2	0	2	1	2	3	1	1	1	1	2	3	1	2	0	2	2	2	2	3	0	0	36	
14.1	0	0	0	2	0	0	0	0	0	0	2	1	0	0	0	2	1	1	0	0	0	0	0	0	1	1	0	2	0	0	0	0	0	13	
14.2	2	0	0	2	0	0	0	0	0	0	1	1	0	0	0	1	1	1	0	0	0	0	0	0	0	1	1	3	0	1	0	0	0	16	
15.1	0	0	0	2	0	1	0	0	0	0	0	3	3	0	0	0	0	1	1	0	0	0	0	0	0	1	1	1	1	0	3	0	0	18	
15.3	0	0	1	2	0	0	0	0	0	0	2	2	0	0	0	0	0	1	0	0	0	0	0	0	1	1	0	0	3	0	0	0	0	11	
16.3	2	2	2	2	0	2	2	1	1	1	1	1	0	1	1	1	1	1	1	1	2	2	0	1	1	1	1	1	1	1	1	0	0	2	36
16.5	1	1	1	1	2	2	2	1	2	0	2	2	0	1	1	2	2	1	2	1	2	2	2	2	2	2	2	2	2	2	2	3	2	0	49
DEP	33	18	31	33	16	31	20	18	27	9	26	32	16	23	18	33	30	20	29	20	29	29	28	20	22	25	27	23	28	30	19	11			

Figure 3. Cross-impact matrix of 32 prioritized global targets and their interactions in the Brazilian context.

The results of MDI could be plotted in a direct influence/dependence chart that shows the current perceptions of experts about the implementation of the SDG framework at the national level, following the stages of a generic policy-planning toward global targets achievement by 2030 (Figure 4).

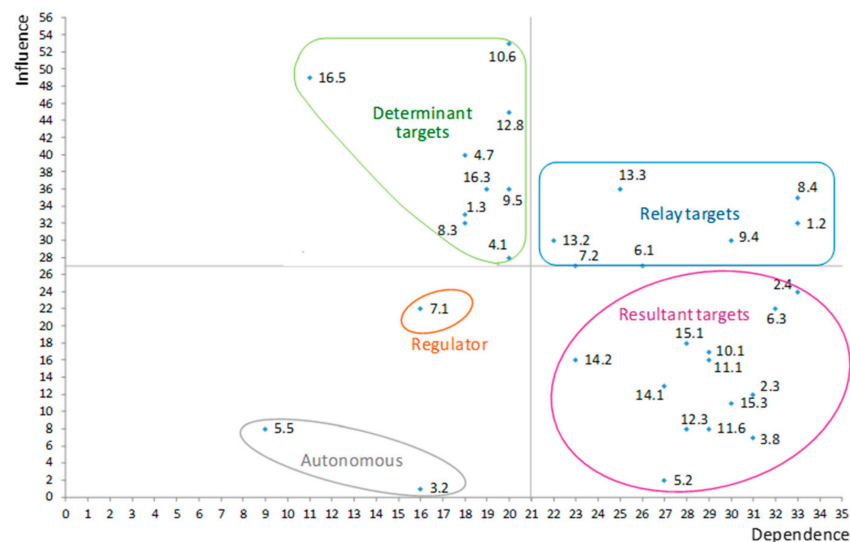


Figure 4. The influence-dependence chart of direct interactions between global targets.

During the next step, the roles played by the variables (if determinants, relays, resultants, or regulators) were identified. Excel[®] was used to calculate the indirect influence and dependence of each variable. MDI was then raised to the sixth power until the overall ranking of the variables' influence and dependence remained constant. The resultant stable matrix, called Matrix of Indirect Influence (MII), determined the indirect influences between all targets over others.

Additionally, the results of MII could be plotted in an indirect influence/dependence chart, as shown in Figure 5. The position of each variable in the influence–dependence chart of indirect interactions between global targets indicated the determinant, relay, resultant, regulator, and autonomous targets.

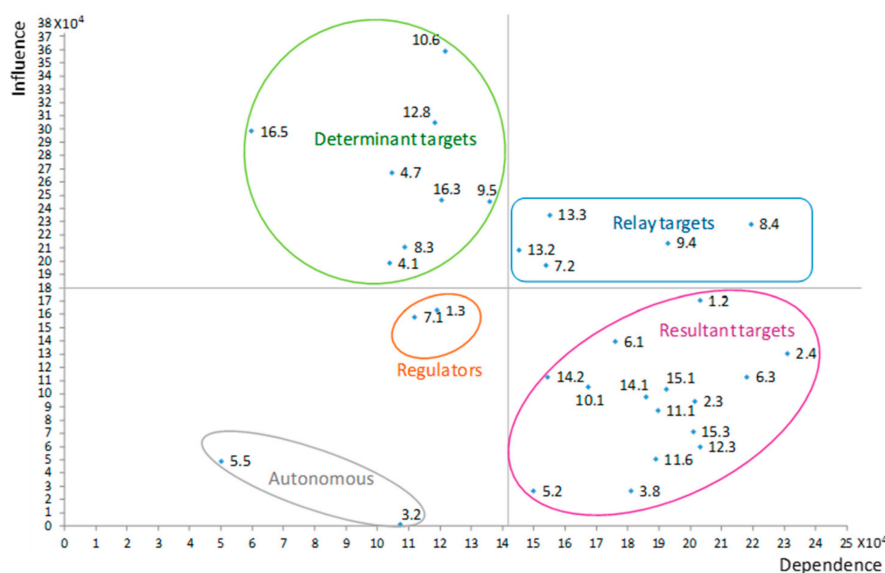


Figure 5. The influence–dependence chart of indirect interactions between global targets. **Legend:** 1.2—Reduction of poverty; 1.3—Social protection; 2.3—Agricultural productivity/small-scale food producers; 2.4—Sustainable food production/agriculture; 3.2—Preventable deaths of newborns/under-5 mortality; 3.8—Health coverage; 4.1—Primary and secondary education; 4.7—Knowledge and skills for sustainable development; 5.2—Elimination of violence against all women and girls; 5.5—Women’s participation and equal opportunities for leadership; 6.1—Drinking water for all; 6.3—Improvement of water quality; 7.1—Universal access to energy; 7.2—Renewable energy; 8.3—Decent work, innovation and economic growth; 8.4—Resource efficiency; 9.4—Upgraded infrastructure; 9.5—Research and development; 10.1—Economic equality; 10.6—Enhanced representation and voice for developing countries in decision-making in global international economic and financial institutions; 11.1—Affordable housing; 11.6—Reduction of environmental impact of cities; 12.3—Reduction of food losses; 12.8—Information and awareness for sustainable development; 13.2—Climate change policy/planning; 13.3—Education and institutional capacity on climate change; 14.1—Reduction of marine pollution; 14.2—Healthy and productive oceans; 15.1—Terrestrial and inland freshwater ecosystems and their services; 15.3—Land degradation-neutral country; 16.3—Equal access to justice for all; 16.5—Reduction of corruption and bribery.

These empirical results highlighted the determinant targets that play a central role in the planning and implementation of the 2030 Agenda in Brazil, as following: target 10.6 (“Enhanced representation and voice for developing countries in decision-making in global international economic and financial institutions”), followed by targets 12.8 (“Information and awareness for sustainable development”); and target 16.5 (“Reduction of corruption and bribery”).

4.4. Phase IV: Network Analysis for Calculating Weighted Centrality Metrics and Visualizing the Full Network and Subnetworks of Global Targets

During this phase, the indirect cross-impact matrix and its corresponding influence–dependence chart (Figure 5) could be reinterpreted in a full network with the interlinkages between all 32 targets prioritized for the Brazilian 2030 Agenda, using the Gephi network package and the Fruchterman and Reingold’s algorithm [35].

Figure 6 depicts a better visualization of the data and a more comprehensive perception of the interlinkages between these targets.

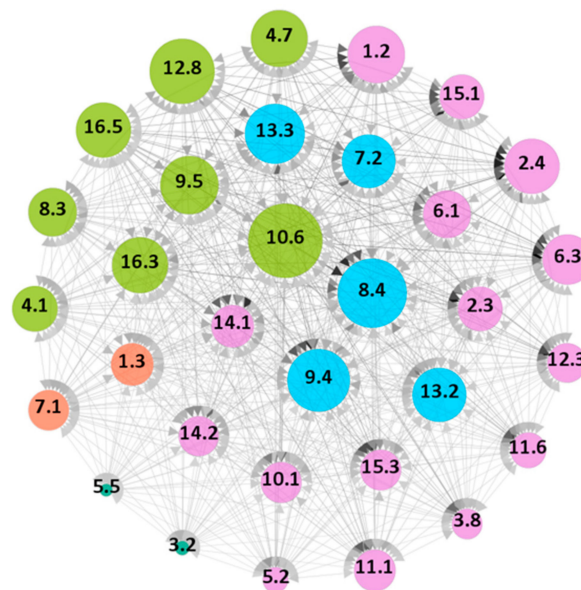


Figure 6. Network analysis of interactions between 32 targets based on the Matrix of Indirect Influence (MII). Note: Green nodes—determinant targets; blue nodes—relay targets; violet nodes—resultant targets; orange nodes—regular targets; and turquoise nodes—autonomous targets.

Figure 6 shows that the size of the nodes (targets) is proportional to the weighted degree centrality, which is based on the number of the node's interactions weighted by the strength of each edge. Additionally, the color intensity of the edge is proportional to the interlinkage strength, so stronger connections are darker, while weaker interlinkages are lighter.

Based on this analysis, the target 10.6 ("Enhanced representation and voice for developing countries in decision-making in global international economic and financial institutions") is the most important target within the full network, due to its greater interaction with other targets, followed by targets 8.4 ("Resource efficiency"), 12.8 ("Information and awareness for sustainable development"), and 9.4 ("Upgraded infrastructure"). Conversely, the lowest influencers in this network are the targets 3.2 ("Preventable deaths of newborns/under-5 mortality") and 5.5 ("Women's participation and equal opportunities for leadership"), considered as autonomous targets according to the classification proposed by Godet [30].

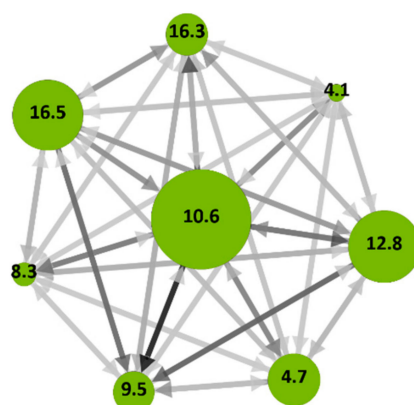
Table 15 presents the results concerning the subnetwork of determinant targets for the implementation of the Brazilian 2030 Agenda, applying three centrality metrics. Regarding this subnetwork, the weighted out-degree centrality was the metric of choice, due to the role played by these targets.

Looking at Table 15, the results suggest that the weighted out-degree centrality is more relevant than the weighted in-degree metric for the analysis of the subnetwork of determinant targets. This choice can be justified by the expansive behavior of these targets that have stronger output than input edges.

Figure 7 shows the subnetwork of determinant targets interlinkages (visualized by weighted out-degree centrality), according to data from the second column of Table 8.

Table 15. Network analysis of the determinant targets for the implementation of the Brazilian 2030 Agenda.

Target	Short Description	Network Analysis Metrics		
		Weighted in-Degree Centrality	Weighted Out-Degree Centrality	Weighted Degree Centrality
10.6	Enhanced representation and voice for developing countries in decision-making in global international economic and financial institutions	121,850,836	358,866,419	480,717,255
12.8	Information and awareness for sustainable development	118,412,220	304,937,068	423,349,288
16.5	Reduction of corruption and bribery	59,751,660	301,876,644	361,628,304
4.7	Knowledge and skills for sustainable development	104,646,274	266,768,798	371,415,072
16.3	Equal access to justice for all	120,545,753	246,586,874	367,132,627
9.5	Research and development	135,931,045	245,157,625	381,088,670
8.3	Decent work, innovation and economic growth	108,925,216	210,747,423	319,672,639
4.1	Primary and secondary education	103,931,160	198,413,781	302,344,941

**Figure 7.** Network analysis of interactions between determinant targets: weighted out-degree centrality.

This subnetwork displays the influence exerted by nodes classified as determinant targets. Bigger nodes are greater influencers than smaller ones, and darker edges are stronger than lighter edges.

Targets 10.6 (“Enhanced representation and voice for developing countries in decision-making in global international economic and financial institutions”), 12.8 (“Information and awareness for sustainable development”) and 16.5 (“Reduction of corruption and bribery”) seem to exert the greatest influence on the other targets. Additionally, Figure 7 reveals that target 9.5 (“Research and development”) is influenced significantly by targets 10.6, 12.8, and 16.5.

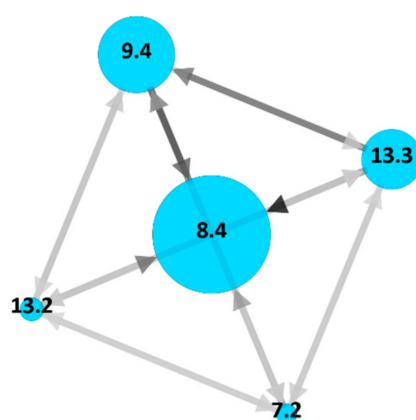
It is worth noting that all eight determinant targets are related directly to government action through public policies.

Table 16 presents the results from the network analysis concerning the relay targets for the implementation of the Brazilian 2030 Agenda, applying three centrality metrics. These results revealed a balance between the input and output weighted degrees of the targets in line with the role played by relay targets. So, in this case, we used the weighted degree centrality, which means the sum of the in-degree and out-degree.

Table 16. Network analysis of the relay targets for the implementation of the Brazilian 2030 Agenda.

Target	Short Description	Network Analysis Metrics		
		Weighted in-Degree Centrality	Weighted Out-Degree Centrality	Weighted Degree Centrality
8.4	Resource efficiency	219,473,688	228,177,568	447,651,256
9.4	Upgraded infrastructure	192,801,751	213,712,641	406,514,392
13.3	Education and institutional capacity on climate change	155,221,707	235,001,786	390,223,493
13.2	Climate change policy/planning	145,338,075	208,493,319	353,831,394
7.2	Renewable energy	153,928,080	196,813,414	350,741,494

Figure 8 shows the subnetwork of relay target interactions based on the weighted degree centrality.

**Figure 8.** Network analysis of interactions between relay targets: weighted degree centrality.

This subnetwork shows the sum of the influence exerted (out-degree centrality) and the influence received (in-degree centrality) by the relay targets. The analysis of this network suggests that targets 8.4 (“Resource efficiency”) and 9.4 (“Upgraded infrastructure”) are the greatest influencers in this cluster. Moreover, Figure 8 reveals that the stronger influences on target 8.4 (“Resource efficiency”) are exerted by targets 13.3 (“Education and institutional capacity on climate change”), 9.4 (“Upgraded infrastructure”), and 13.2 (“Climate change policy/planning”).

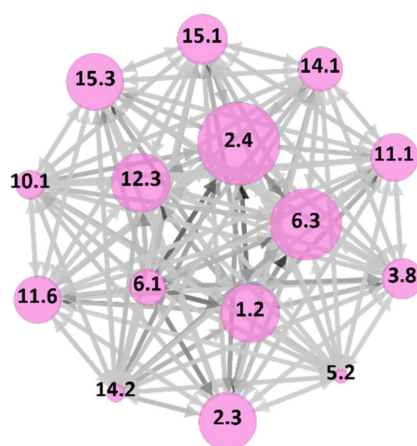
These results mean that investments on target 13.3, 9.4, and 13.2 will result in positive support for the target 8.4, and so on.

Table 17 presents the results from the network analysis concerning the resultant targets for the implementation of the Brazilian 2030 Agenda, applying three centrality metrics. To generate the corresponding subnetwork graph, the weighted in-degree centrality was employed due to the dependence behavior of these targets.

Table 17. Network analysis of the resultant targets for the implementation of the Brazilian 2030 Agenda.

Target	Short Description	Network Analysis Metrics		
		Weighted In-Degree Centrality	Weighted Out-Degree Centrality	Weighted Degree Centrality
2.4	Sustainable food production/agriculture	231,155,804	130,277,727	361,433,531
6.3	Improvement of water quality	218,115,183	112,635,811	330,750,994
1.2	Reduction of poverty	203,175,038	170,303,538	373,478,576
12.3	Reduction of food losses	203,150,908	59,860,758	263,011,666
2.3	Agricultural productivity/small-scale food producers	201,576,259	94,299,711	295,875,970
15.3	Land degradation-neutral country	200,994,992	71,105,006	272,099,998
15.1	Terrestrial and inland freshwater ecosystems and their services	192,357,488	103,222,309	295,579,797
11.1	Affordable housing	189,793,182	87,461,939	277,255,121
11.6	Reduction of environmental impact of cities	189,156,308	50,383,308	239,539,616
14.1	Reduction of marine pollution	185,827,649	97,418,614	283,246,263
3.8	Health coverage	181,159,391	26,569,533	207,728,924
6.1	Drinking water for all	176,012,055	139,477,806	315,489,861
10.1	Economic equality	167,531,138	104,997,678	272,528,816
14.2	Healthy and productive oceans	154,512,435	112,828,199	267,340,634
5.2	Elimination of violence against all women and girls	149,884,725	26,303,136	176,187,861

Figure 9 shows the subnetwork of resultant targets interactions (weighted in-degree centrality).

**Figure 9.** Network analysis of interactions between the resultant global targets: weighted in-degree centrality.

Bigger nodes are more influenced by other targets than smaller ones and, as well, darker edges are stronger than lighter ones. Targets 2.4 (“Food production/agriculture”), 6.3 (“Improvement of water quality”) and 1.2 (“Reduction of poverty”) seem to receive the greatest influence from other targets within this subnetwork, whereas targets 10.1 (“Economic equality”), 14.2 (“Healthy and productive oceans”), and 5.2 (“Elimination of violence against all women and girls”) receive less influence from the other targets of this subnetwork.

Moreover, Figure 9 leaves us to assume that the stronger influence on the graph is exerted by target 1.2 (“Reduction of poverty”) on the other targets, especially to targets (“Food production/agriculture”), 6.3 (“Improvement of water quality”), 12.3 (“Reduction of food losses”), 2.3 (“Agricultural

productivity/small-scale food producers), 15.3 (“Land degradation-neutral country”), 15.1 (“Terrestrial and inland freshwater ecosystems and their services”), 11.1 (“Affordable housing”) and 11.6 (“Reduction of environmental impact of cities”).

The resultant targets do not have a preponderant target driving other targets. Instead, the cluster appears to share governance between diverse actors—government, industry, service sectors, and society through public-private partnerships and cooperative arrangements.

To conclude this phase, it is worth mentioning that, initially, the influence/dependence of regulator and autonomous targets had been considered in preliminary network analysis. However, their influence/dependence in the full network (Figure 6) shows that subnetworks of regulator and autonomous targets were not relevant for visualization purposes.

5. Discussion of Findings and Policy Implications

Taking the methodological point of view, the results reported in Section 4 confirmed the contributions of the proposed framework concerning the research gaps discussed in the introductory section of this work. Additionally, it brought insights for future decision-making processes related to all stages of a generic policy planning toward global targets achievement by 2030.

Focusing more specifically on the Brazilian context, the first important finding is that the 32 prioritized global targets are mutually supportive since there are more positive than negative links within the Matrix of Direct Influence (MDI) (Figure 3).

The second most relevant finding is that it was possible to distinguish the 32 prioritized targets into three main clusters, as follows: (i) determinant targets (10.6; 12.8; 16.5; 4.7; 16.3; 9.5; 8.3, and 4.1); (ii) relay targets (8.4; 9.4; 13.3; 13.2, and 7.2); and resultants (2.4; 6.3; 1.2; 12.3; 2.3; 15.3; 15.1; 11.1; 11.6; 14.1; 3.8; 6.1; 10.1; 14.2, and 5.2).

Regarding a foresight perspective, we center our discussion on the influence-dependence chart of indirect interactions between global targets, focusing on the referred clusters (Figure 5). Initially, we discuss the results concerning determinant targets since they play a driving role in the implementation of the country’s 2030 Agenda as a whole (see Figure 6). Secondly, we highlight the role played by the relay targets because any action on these targets will have consequences on resultant ones; and finally, we focus on the results regarding resultant targets.

Taking a network perspective, considering the ranking results of determinant targets (Table 15), we have found that progress in targets 10.6 (“Enhanced representation and voice for developing countries in decision-making in global international economic and financial institutions”), 12.8 (“Information and awareness for sustainable development”), and target 16.5 (“Reduction of corruption and bribery”) can generate the most positive influence on the remaining global targets in Brazil.

Concerning target 10.6, agreements and commitments have been signed to expand and consolidate the Brazilian presence in international economic and financial institutions, especially in the International Monetary Fund (IMF), as well as in the World Bank, and the G-20. The Brazilian Government has supported the G20 agenda of improving international financial regulation and committed to implementing the agreed regulatory reforms, seeking convergence with international standards, and security of the national and international financial system [22].

Related to target 12.8, one of the main challenges in Brazil for achieving SDGs is changing the current patterns of production and consumption and establishing new pathways to sustainable development. Adding particular consideration for environmental issues, the Federal Constitution, enacted in 1988, included a specific chapter on such issues and established environmental education as a civil right. It is necessary to increase the efforts to strengthen the capacities of educators and educational institutions engaged in the implementation of the National Environmental Education Program (ProNEA, acronym in Portuguese). This Program was created in 2003 to “ensure, at the educational level, the balanced integration of multiple dimensions of sustainability—environmental,

ethical, cultural, spiritual, political, and economic—promoting the dignity, care, and valuation of every form of life on the planet” [38].

The strengthening of Brazilian institutions through the fight against corruption and bribery is a crucial requirement for achieving sustainable and inclusive development, as established in target 16.5. Recently, Brazil has been very sensitive toward successive corruption scandals, either by the Executive and Legislative branches or by the Judiciary, employing new applications of the current legislation. There was an average of 261 disciplinary inquiries filed to investigate receipt of undue advantages in the sphere of the Federal Executive Power between 2014 and 2015. This number rose to 322 between 2016 and 2017. During 2016, 17 processes of Private Entity Accountability were filed, whilst 132 were filed in 2017 [39]. A special emphasis should be put on the “Lava Jato Task Force” that “has revealed criminal schemes and, in doing so, challenged powerful politicians and business people in more than a dozen countries and on at least three continents. The investigations initiated in Brazil have effectively unraveled corrupt networks, recovering unprecedented amounts of public resources and prosecuting powerful individuals, many of whom have confessed to their crimes [40] (p.1).

However, in spite of all such advances, they did not prevent Brazil from occupying the 105th position (on a list of 180 countries) in the 2018 Global Ranking of Corruption Perception published by Transparency International [41]. This is due to the practical ineffectiveness of many laws and a number of control institutions suffering from lack of support, and human and financial resources. According to Leite and Teixeira [42] (p. 39), “the world trend is to sectorize corruption, looking at its specificities in areas such as health, sports, and politics, but Article 317 of the Brazilian Penal Code defines a comprehensive type of corruption, and this model is outdated and must be reviewed”. Also, in terms of money laundering, legislation that defines the final beneficiary and guarantees protection for the complainant in good faith has not yet been drafted [39].

Continuing the analysis of the determinant global targets in the Brazilian context, targets 4.1 (“Primary and secondary education”), 4.7 (“Knowledge and skills for sustainable development”), 9.5 (“Research and development”), and 8.3 (“Decent work, innovation and economic growth”) can be considered the knowledge-drivers for achieving most relay and resultant targets in the Brazilian context.

Concerning the primary and secondary education leading to relevant and effective learning outcome (target 4.1), lower educational achievement in Brazil tends to be associated with higher income inequality. The country has one of the most significant shares of adults without upper secondary education and one of the highest income inequalities of all the Organisation for Economic Co-operation and Development (OECD) and partner countries [39]. As noted by OECD [43] (p.1), “nearly one-quarter of children under the age of 3 are enrolled in early childhood education, close to the OECD average and above most other Latin American countries with available data. Enrolment rates fall sharply after the age of 14 in Brazil: only 69% of 15–19-year-olds and 29% of 20–24-year-olds are enrolled in education”. Brazil has been investing a relatively high share of both its gross domestic product (GDP) and its total public expenditure on education. However, spending per student still lags behind most OECD and partner countries [40].

Related to targets 9.5 and 8.3, the annual edition of the Global Innovation Index (GII) 2019, released by the World Intellectual Property Organization (WIPO) in partnership with Business School Insead and Cornell University, points out that Brazil ranks in 66th position on a list of 129 countries, behind all the BRIC nations (Brazil, Russia, India and China) and down two positions from 2018 [44]. Over the last decade, the Brazilian position in the GII ranking has been declining, fluctuating around the 60th and 70th places. There are three critical barriers to innovation in the country: (i) lack of consistent fiscal support; (ii) failure to invest in long-term skills capability; and (iii) low performance in terms of patented inventions.

Regarding the achievement of target 16.3 (“Equal access to justice for all”) is concerned, although there are still many measures to be taken, a great step forward was given through the so-called first access to justice wave of renewal, since the enact of the Brazilian Federal Constitution in 1988. This first wave granted access to justice to the majority of the poor population in the country through the

Special Courts, the Public Defenders Offices in almost all states, and the growth of conciliatory justice. According to Grinover et al. [45] (p. 35): “with regards to the so-called second wave of renewal, Brazil was a pioneer among civil law countries in establishing legal protection of collective interests, which is constantly being upgraded. The third wave of renewal—with focus on proceedings—is subject to current and permanent experts’ concerns, which result in the introduction of new mechanisms in the system aimed at accelerating, reducing formalization, and digitalizing the process, alongside the project of a new Code of Civil Procedure”.

Now, focusing specifically on relay targets (Table 16), we have found that progress in targets 8.4 (“Resource efficiency”), and 9.4 (“Upgraded infrastructure”) has a great influence on the resultant targets’ achievement, but they also are highly influenced by determinant targets.

Several challenges and opportunities for the country are related to target 8.4, whose development model is based on primary activities such as mineral extraction and agricultural monocultures. The basic materials footprint in Brazil, an important index of resource efficiency in the economy, is in a critical situation in large- and medium-sized cities (currently between 0.6 and 0.8 IEFI—Integrated Environmental Footprint Index). Brazil is placed in the 79th position according to the Integrated Environmental Footprint Index [39].

Figure 8, as mentioned before, reveals that the stronger influences on target 8.4 (“Resource efficiency”) are exerted by targets 13.3 (“Education and institutional capacity on climate change”), 9.4 (“Upgraded infrastructure”), and 13.2 (“Climate change policy/planning”). So, investments on targets 9.4, 13.3, and 13.2 will result in positive support for target 8.4, and so on.

Target 9.4 refers to upgrades to 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 [46]. The life-cycle of products should be taken into consideration right from the design stage, with the allocation of responsibilities and deadlines for agents. A transition strategy for a circular economy model should be addressed to the main sectors of the Brazilian economy, focusing on regenerative business models and conservation of biodiversity.

Referencing target 13.3, this would be driven by a more effective basic education policy (target 4.1) addressed to training for teachers and strengthening literacy and mathematics skills, including environmental education as a cross-cutting subject. The National Environmental Education Policy (Pnea, acronym in Portuguese), instituted by Law 9795 of April 27, 1999, and the National Environmental Education Program (Pronea, acronym in Portuguese) would further boost the existing climate change policies (13.2).

During the 21st United Nations Climate Change Conference (COP-21) in Paris, the Nationally Determined Contributions (NDCs) submitted by the country set an absolute emission reduction of 37% until 2025 and 43% until 2030, having as its base 2005 levels. Thus, the engagement of land use, renewable energy, and low carbon agriculture sectors is key for the Brazilian commitments.

According to NDC Brazil, the intention is to adopt the following measures: (i) increasing the share of sustainable biofuels in the Brazilian energy mix to approximately 18% by 2030, especially ethanol supply, which is already responsible for 6.6% of all energy consumed in the country in 2018 [47]; (ii) in land use change and forests, although the number of burnings has increased in the Amazon Forest in recent years, the commitment is strengthening and enforcing the implementation of the Forest Code (Law 12,651, May 25, 2012), at federal, state and municipal levels; (iii) considering the energy sector, the goal, already reached in 2019, would be to reach 45% of renewables in the energy mix by 2030, especially raising the share of wind, biomass and solar energy, and also increased by 10%, energy efficiency; (iv) in the agriculture sector, the commitment is to reinforce the Low Carbon Emission Agriculture Program (ABC Program) as the main strategy for sustainable agricultural development; (v) in the industry sector, promote new standards of clean technologies and further enhance energy efficiency measures and low carbon infrastructure, increasing the coverage of the Brazilian Labeling Plan [48] for refurbished motors [49]; and (vi) in the transportation sector, the most inefficient energy

sector in Brazil, to promote efficiency measures, and improve infrastructure for transport and public transportation in urban areas.

Regarding target 7.2, increasing substantially the share of renewable energy would be more effective with advances in policies that boosts research and development (target 9.5), and innovation in the energy market (related to target 8.3). Considering Brazil, in 2018, 45% of the energy was supplied by renewable sources, thanks to the large hydroelectric plants that were built mostly in the 60s and 70s.

Recently, the construction of new hydroelectric plants, among them Belo Monte, generated great discussion about their sustainability since they cause a great environmental and social impact because they were built in the Amazon region [50].

There also has been an impressive increase in wind power generation in the last 10 years, contributing to about 10% of the installed capacity [47]. Furthermore, solar power generation contributes to about 1% of all installed capacity. Given the intermittent nature of these two sources of power generation, and the complexity of the operation of the Brazilian System (almost completely connected and continental in size), it is important that planners in the electricity sector invest in smart technologies, bringing more innovation to this sector. Additionally, this would be an opportunity for the country to have a more efficient transport system, focused on electric mobility, and whose mix was predominantly renewable (solar, wind, and biomass).

Finally, focusing on the resultant subnetwork, the most influenced targets are target 2.4 ("Sustainable food production/agriculture"); target 6.3 ("Improvement of water quality"); target 1.2 ("Reduction of poverty"); and target 12.3 ("Reduction of food losses").

Obtaining data on food losses is a challenge in Brazil. The Brazilian Agricultural Research Corporation (acronym in Portuguese, Embrapa) acknowledges that the country does not have precise national-wide information on this issue. The World Resources Institute Brazil (WRI Brazil) estimates that the country wastes 41,000 tons of food per year, which means it is among the ten most wasteful countries in the world.

Among recommendations for policy purposes presented in the Civil Society Working Group for the 2030 Agenda [39], we highlight the following: (i) adoption of the 2016–2019 National Food and Nutritional Safety Plan as a benchmark for policy in the sector; (ii) return the current structure of the National Rural Sustainable Development Council (Condraf, acronym in Portuguese) to being a participative space for social movements in rural areas and those working with waters and forests; (iii) redraft the budget of the "Water for All" Program, with a focus on the continuation of the "One World and Two Waters (P1+2)" Program; (iv) address poverty from a multi-dimensional perspective, including different social determinants that reinforce the conditions of its existence, such as race, ethnic background and gender, in the policies and programs designed to fight it; and (v) implementation of a National Policy for Fighting Food Waste and Loss, incorporating an order of priority (no-waste, reduction, reuse and treatment), and considering the waste produced by final consumers, since a large part of the waste sent to landfills is still organic.

6. Conclusions

An attempt was made to demonstrate, in practice, the benefits of adopting a systemic and contextual framework to prioritize SDG targets for a country's 2030 Agenda, from a foresight perspective. The main contributions of this work to the advancement of the existing literature, both theoretical and empirical, can be synthesized as follows: (i) the use of fuzzy-AHP-TOPSIS method in the first two phases of the framework could absorb the subjectivity and the imprecision of expert judgments into the process of ranking alternative targets associated to each SDG; (ii) the adoption of PSA allowed for highlighting and describing the roles (current and future) played by the key global targets in all the stages of a generic policy-planning toward global targets achievement by 2030; (iii) the network analysis provided better visualization of the interactions between targets in two levels (full network, and subnetworks related to the clusters identified by PSA, namely determinant, relay, and resultant targets); and (iv) the ranking

results of global targets against weighted centrality metrics also could indicate the targets that play a central role in the full network, as well in subnetworks of determinant, relay, and resultant targets.

The integration of fuzzy multicriteria decision-making methods (fuzzy-AHP-TOPSIS), prospective structural analysis (PSA), and network theory tools proved to be very useful in the opinion of the experts who participated in the socio-technical experiment in Brazil from August to November 2018. This experiment especially was designed to bring methodological insights into the decision-making processes related to the definition of the Brazilian 2030 Agenda. Its results confirmed the basic assumptions and desired qualitative characteristics of the conceptual framework designed for prioritizing global targets at the national context.

Finally, the ranking results of determinant targets against weighted centrality metrics (Table 15) indicate that targets 10.6 (“Enhanced representation and voice for developing countries in decision-making in global international economic and financial institutions”); 12.8 (“Information and awareness for sustainable development”); and 16.5 (“Reduction of corruption and bribery”) are the most influential targets attributable to their multiple central roles played by them. Conversely, the most influenced targets from the resultant subnetwork are target 2.4 (“Sustainable food production/agriculture”); target 6.3 (“Improvement of water quality”); target 1.2 (“Reduction of poverty”); and target 12.3 (“Reduction of food losses”).

Although the empirical results presented in this paper are exclusive to Brazil, we believe that the proposed framework can be replicated in other countries, especially those that are going to prioritize the global targets to be included in their respective Agendas. This assumption is in line with the proposal by Nilsson et al. [18] to create a knowledge platform for assembling, systematizing, and aggregating knowledge on SDGs and global target interactions.

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