Sustainable Development Goal interactions: an analysis based on the five pillars of the 2030 Agenda

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Abstract:

The 2030 Agenda calls for a change in thinking in order to implement sustainable development goals (SDGs) and targets as a system. To achieve this goal, the 2030 Agenda established five pillars ('5 Ps'): people, planet, prosperity, peace and partnership. Here, we present a classification of these SDGs and their targets based on the five pillars. Our aim is to improve our understanding of interactions by assessing whether potential synergies and trade-offs are related to the classification of the targets. We surveyed 30 people and asked them to associate the content of target labels with the pillars. We classified SDG and targets according to an original quantification system. We determined whether the interactions were linked to similar or different classifications of the targets. We observed that the more similar the targets were in terms of classification, the more positive the interactions. We also noted that synergies exist between targets of different classifications. Our findings are useful for applying a systemic approach for policy coherence in sustainability analysis.

Keywords: 2030 Agenda – Interlinkages – Sustainable Development Goals – Systemic sustainability analysis – Policy coherence – SDG classification – Sustainable development

Introduction

In 2015, the United Nations General Assembly adopted the 2030 Agenda for Sustainable Development with its 17 Sustainable Development Goals (SDGs) and 169 targets (United Nations, 2015). Building on the earlier work of the Millennium Development Goals (Caballero, 2019; Helgason, 2016), the 2030 Agenda is based on the principles of universality, inclusion—reflected by the 'leaving no one behind' motto—and integrality. The SDGs and targets are relevant to all countries and all actors, while also being conceived as indivisible. The 2030 Agenda therefore calls for a paradigm shift that overcomes conceptual, sectoral and institutional silos and implements SDGs and targets as a system, i.e., a set of networking elements having multiple, rippling and sometimes reciprocal influences (International Council for Science, 2017; International Council for Science & International Social Science Council, 2015; Le Blanc, 2015; Lusseau & Mancini, 2019; Nilsson et al., 2018; Pradhan, 2019; Smith et al., 2018; Zhou & Moinuddin, 2017). This paradigm favours innovative approaches that implement sustainable development and engage a wide range of stakeholders through a transversal approach that respects people in their diversity of cultures and knowledge (Villeneuve et al., 2015). Unlike a sectoral- or silo-based approach, a transversal approach is multidimensional and multi-actor, thereby creating opportunities for dialogue and exchange between different knowledges and stakeholders (Riffon et al., 2013).

Inspired by the systems approach, Blue Plan (2005) developed a systemic sustainability analysis (SSA) 'to understand the world as shared perceptions of systems, to engage with complexity, to solve problems and to address issues of perspective and context.' In line with integrating the principles of the 2030 Agenda, Villeneuve et al. (2015) wrote that SSA 'allows to put into perspective the multiple dimensions of sustainable development, the synergies and the trade-offs between the goals and the means of implementation to achieve them.' For Sala et al. (2015), sustainability assessment 'is one of the most complex types of appraisal methodologies.' It entails multidisciplinary aspects and is conducted to support decision-making and policy development.

A study of 26 countries (Allen et al., 2017) concluded that both implementation and achievement of the SDGs require further work on thematic analyses and the identification of gaps. This study also denoted a limited knowledge of systemic analysis by stakeholders, despite the broad recognition of its importance (Nilsson, 2017; Nilsson et al., 2018). Therefore, the existing research challenge is to develop knowledge about the interactions between the different dimensions of sustainable development (Griggs et al., 2014) and propose approaches that will enable practitioners to integrate systems thinking for its implementation (Nilsson et al., 2018).

The identification of interactions between the various SDG targets is a vast challenge. Few authors have identified, mapped or characterised the interactions between the SDGs and

their targets through qualitative analysis. This includes the incipient literature that relies on different methodologies to identify and characterise such interactions across different dimensions, such as levels of governance (from global to local), sectors of economic activities, or institutional actors (Coopman et al., 2016; International Council for Science, 2017; Le Blanc, 2015; McCollum et al., 2018; Nilsson, 2017; Vladimirova & Le Blanc, 2016; Waage et al., 2015; Weitz et al., 2018; Zhou & Moinuddin, 2017). Others, including Pradhan et al. (2017), Lusseau and Mancini (2019) and Kroll et al. (2019), have proposed a systemic quantitative analysis of SDG interactions.

Previous studies have identified interactions between SDGs, between SDGs and their respective targets, and between targets only. A key observation is that none of these studies are applied to all 169 targets. To explain this incomplete coverage, the various authors state that their work contributes only to a sectoral study (e.g., education) or to a particular event (e.g., High-level Political Forum); they also indicate the narrow scope of their task or the lack of data and knowledge for all 169 targets. A global indicator framework of 231 unique indicators has been developed by the Inter-Agency and Expert Group on SDG indicators (IAEG-SDGs) for monitoring achievement of the SDGs (United Nations Statistics Division, 2020b). The IAEG-SDGs classified the indicators into three tiers on the basis of 'their level of methodological development and availability of data at the global level' (United Nations Statistics Division, 2020a). In May 2019, the Global Sustainable Development Report 2019 stated that no methodology had been established for 34 indicators (Tier III) (Independent

Group of Scientists appointed by the Secretary-General, 2019). As of April 2020, the global indicator framework did not contain any Tier III indicators. This absence highlights how data related to the 169 targets remain missing and how the monitoring of multiple indicators has yet to begin.

The 2030 Agenda established five areas of critical importance, better known as the five pillars or the '5 Ps': *People*, *Planet*, *Prosperity*, *Peace* and *Partnership* (Gusmão Caiado et al., 2018; Jayasooria, 2016). The Agenda 'is a plan of action for **people**, **planet** and **prosperity**. It also seeks to strengthen universal **peace** in larger freedom. All countries and all stakeholders, acting in collaborative **partnership**, will implement this plan' (United Nations, 2015). Although many organisations, authors and countries differ in how they classify the SDGs across the five pillars (Table 1), these pillars are used to structure Common Country Assessments (CCA), Voluntary National Reviews (VNR), policies, strategies, programmes and other reports. Table 1 presents the classification of SDGs as derived from a systematic review of the 2017 and 2018 CCAs and VNRs. We also added other SDG classifications that we found in our literature review. However, no explicit methodology has been articulated to explain the various classifications, which are essentially based on the wording of the 17 SDGs, without any reference to a deeper target level.

This paper proposes the first comprehensive classification of the SDGs and their targets based on the five pillars. This classification serves to improve our understanding of SDGs

and target interactions by assessing whether potential synergies and trade-offs are related (or not) to the classification of targets. We hypothesise that synergies are more frequent when targets are of the same classification, and trade-offs are more frequent when targets are of a different classification.

For our classification system, we surveyed experts and non-experts by asking them to associate the contents of target labels with one or more (up to 5) corresponding pillar categories. We then classified each SDG and target by applying an original quantifying system. We also identified potential interactions evaluated using the seven-point typology developed by Nilsson et al. (2016) and ICSU (2017). We measured whether positive and negative interactions were linked to similar or different classifications for the targets.

In the following sections, we detail the methodology used to gather and analyse our data. We present the main results of our classification and analyse relations between the classification of targets and the interactions that we identified from the literature. We then discuss how these results improve our knowledge of the systemic approach for implementing the SDGs and how this analysis enhances policy coherence and the systemic analysis of sustainability. Finally, we consider the limits of our research and evaluate how it can be used in future studies.

Methods

To produce our classification of targets based on the five pillars, we first distributed an online survey across several professional networks, with the objective of reaching a maximum number of participants from different fields related (or not) to sustainable development. We chose an online survey tool: LimeSurvey (LimeSurvey Project Team, 2012). We asked participants to associate all 169 targets to the five pillars. The time required to fill out the survey was approximately two hours; the necessary time commitment of the participants made a high response rate difficult to obtain. Among the 30 respondents who completed the full survey, 25 mentioned having an occupation related to sustainable development. Most participants were professionals (19), five (5) were students, two (2) were pensioners, two (2) were executives, one (1) was a technician, and one (1) respondent did not mention their professional status. The most represented activity sectors were natural resources, agriculture, wildlife and environment (12), followed by education, education sciences, humanities and social sciences (10). Among the participants who provided personal information (24), 75 per cent were men, and 79 per cent were from OECD countries.

In the survey, each page represented one SDG. The definition of the five pillars, as worded in the 2030 Agenda (United Nations, 2015), was presented at the beginning of each page. For each target, we also mentioned their indicators (United Nations, 2018). The following

instructions regarding each of the 169 targets were given to participants: i) Read the label of the target; ii) Associate the content of the target with one or more corresponding pillars. The target can be associated with 1, 2, 3, 4 or even all 5 Ps of the Agenda. Participants were asked to stay as close as possible to the content of a target label in order to limit any extensive interpretation. The SDG indicators were also provided, presenting more information if the content of a target was unclear to participants. We requested the participants not to interpret the content of the targets beyond what was suggested by the label.

To classify the targets—and as no published classification could be applied to our study— we developed a scoring system based on the level of exclusiveness or inclusiveness of a pillar. If a single pillar is associated with a target, we assumed the link is stronger between the target and the pillar than if it were linked to many pillars. This score was based on the following scores allocated to each target, for each response:

- Target associated with 1 P = 1 point for the selected P

- Target associated with 2 Ps = 0.5 points for each selected P

- Target associated with 3 Ps = 0.33 points for each selected P

- Target associated with 4 Ps = 0.25 points for each selected P

- Target associated with all 5 Ps = 0.2 points for each P

To obtain the classification of a target, we added the scores distributed among the five

pillars from the responses of the 30 participants. Thus, each target was classified on the

basis of the distribution of 30 points within the five pillars (Table 2).

For the classification of targets, we looked at the percentage of global frequency for each

pillar in a target. We kept pillars having the highest score and those with at least half the

score of the main pillar. As well, we retained pillars selected by at least two thirds of the

participants, even if their score was less than half the score of the main pillar.

To classify SDGs and to focus on thematic targets, we summed the scores of each SDG

respective target. In doing so, we discarded targets related to means of implementation

(MoI) (Le Blanc, 2015; Weitz et al., 2018) but kept the SDG 17 targets. MoI encompass

finance, trade, technology transfer and capacity-building (Le Blanc, 2015). They generally

focus on partnership and would have distorted the classification of the SDGs. For our final

classification, we kept pillars having the highest score for each SDG. We also retained those

that obtained at least half the score of the main pillar.

We then tested the correlation between the classifications of all possible pairs of targets.

After discarding the MoI targets, we analysed the potential interactions of the remaining

126 targets. As a target cannot be paired with itself and considering that links are

bidirectional, there are 7875 potential interactions (126 targets × 125 targets without self-pairing)/2 (bidirectional links).

We applied a Pearson correlation coefficient (PCC) using target scores as variables. A high coefficient implies a strong relationship between the classifications of targets, i.e., the final score of each target. Targets of the same classification therefore share a strongly connected distribution of scores to the five pillars. A negative coefficient means that targets have a different classification. The scores of these targets are distributed differently across the five pillars (Table 3).

To validate whether positive and negative interactions truly relate to the classification of targets, we first identified publications studying qualitative interactions at the target level (Coopman et al., 2016; International Council for Science, 2017; Nilsson, 2017; Weitz et al., 2018; Zhou & Moinuddin, 2017), these being the most accurate and specific. However, as mentioned by Zhou and Moinuddin (2017), 'studies that cover all the 169 targets are not yet available'; these studies, however, do not use the same methodology to identify and evaluate interactions. For our research, we looked for as many evaluated interactions as possible. In addition, we wanted these interactions to be assessed on a scale that also differentiated between positive and negative effects. Three studies matched our criteria: ICSU (2017), Nilsson (2017) and Weitz et al. (2018). These studies cover 966 potential interactions and assess them using the seven-point scale typology developed by Nilsson et

al. (2016) and ICSU (2017) (A table summarising the characteristics of publications that assess these interactions is available in the electronic supplementary material). This scale ranges from -3 to +3, depending on the strength and direction of an interaction (Table 4).

We applied linear regression to test the relationship between the scoring of the documented interaction (between -3 and +3) and the level of target similarity represented by the PCC, the latter being used as the dependent variable. We set $P < 0.001$ (t-test) as a threshold for significance of the R^2 (Zar, 1999). Given that some interactions scored within a relatively broad spectrum (e.g., -3/+2), we used both the minimum and maximum interaction scorings when necessary. These variations may come from the same author or different sources and their respective evaluations. We first tested this approach on each publication separately to compare relationships with minimum and maximum potential scores. We then examined the relationships of all possible interaction scores identified in the three publications and created a curve for each possibility, for a total of 1056 assessed interactions. In ICSU (2017), for instance, the interaction between targets 13.1 and 14.2 had potential interaction scores of -3 to +2. In this case, we created a line for each potential score (-3; -2; -1; 1; and 2).

Results

SDGs and target classification

We applied our scoring system to all SDG targets, except for targets focused on MoI, for a total of 126 targets. We used the relative distribution of target scores of each SDG to illustrate the spread of the five pillars (Figure 1). We note that each pillar is present in all 17 SDGs at the target level. The final SDG classification (Table 5) shows that most SDGs are associated with a single pillar (SDGs 3, 4, 5, 9, 12, 14 and 15) or two pillars (SDGs 1, 6, 7, 8, 11, 13, 16 and 17). Only two SDGs are classified in more than two pillars; SDG 2 is associated with three pillars, and SDG 10 is linked with four pillars. The '*People*' pillar is associated with eleven SDGs, '*Planet*' with eight, '*Prosperity'* with seven, while '*Peace*' and '*Partnership*' are each linked to two SDGs.

Our classification of the targets placed 68 targets are under a single pillar, 47 under two pillars and 11 under three pillars. The '*People*' pillar is linked to 60 targets, '*Planet*' to 47 targets, '*Prosperity*' to 43 targets, '*Peace*' to 12 targets and '*Partnership*' to 33 targets (Table 2).

Correlation and interactions between targets

When applying PCC to the target scores of the five pillars, we obtained PCC values ranging between -0.983 and 1. Of the 7875 potential interactions between two targets, 53.4 per cent of the PCCs had a weak or very weak association to the classification of the target PCCs,

and 47 per cent had a strong or very strong association. If we only consider interactions identified and evaluated using the seven-point scale of Nilsson et al. (2016) and the ICSU (2017), 71.7% of these paired targets have a strong (16.5%) or very strong association (55.2%) (Table 6).

Relying on the cross-impact matrix for target interactions of Weitz et al. (2018), we calculated the mean PCC between each target and the SDGs, including the SDG to which they belong (the full matrix, including rankings, is available in the electronic supplementary material).

We averaged the correlations between each SDG and target to identify those most compatible with other SDGs. We then ranked the SDGs and targets from most to least compatible. The mean correlations between PCC and SDGs indicate that the seven most compatible SDGs (3, 1, 11, 4, 6, 2 and 13) are linked with the '*People*' pillar (Table 7). The two least compatible, SDGs 16 and 17, focus mainly on the '*Peace*' (for SDG 16) and '*Partnership*' (for SDG 17) pillars, which are associated only with SDG 10. As for the targets, two from SDG 11 (*Cities and communities*), three from SDG 6 (*Water and sanitation*) and two from SDG 3 (*Health*) are among the top eight targets. In contrast, five targets from SDG 16 (*Peace, justice and institutions*) are found at the bottom of the ranking.

We tested the relationship between potential interactions, using the Nilsson et al. (2016) scale and our PCC, and by including all potential evaluations from our three sources (International Council for Science, 2017; Nilsson, 2017; Weitz et al., 2018) to answer our central research question: Are potential synergies and trade-offs linked with the classification of the targets? The regression shows that targets having different classifications are more likely to have negative interactions, whereas targets sharing similar classifications are expected to have more positive interactions (Figure 2).

Discussion

The implementation of sustainable development and the 2030 Agenda requires an integrated approach, and its implementation cannot be achieved without identifying the interactions between the SDGs and their targets. To apply systems thinking and systemic sustainability analysis, we must characterise the different components of the system and better understand the system as a whole (Nilsson et al., 2018; Weitz et al., 2018).

Many development practitioners and academics have analysed the SDGs to identify the relations between them and among their targets. Researchers also use the five pillars to frame the politics, strategies, programmes and reviews of the 2030 Agenda (cf. Table 1). Although the wording of each SDG appears to focus on a particular pillar (Barbier & Burgess, 2017), one could expect the targets not to align necessarily with this same pillar and rather to reflect more complex associations with multiple pillars. In fact, the various classifications

of the SDGs in our study show that two thirds (14/21) of the publications that we analysed associate a SDG with a single pillar. When we look closer at the classifications (Table 7), we see unanimity for eight SDGs, classified within the same pillar by all publications; nonetheless, we found that these SDGs may also be linked to other pillars. Similarly, there is consensus regarding SDGs 3 and 4 (with '*People*'), SDGs 8 and 9 ('*Prosperity*'), SDGs 13, 14 and 15 ('*Planet*') and SDG 17 ('*Partnership*'). Other SDGs are nearly unanimous: SDGs 1, 2 and 5 (with '*People*') and SDG 16 ('*Peace*') are selected by at least 90 per cent of the surveyed publications. Finally, there is no clear consensus for SDGs 6, 7, 10, 11 and 12. '*Planet*' is the most associated pillar with SDGs 6 and 12, whereas '*Prosperity*' is preferably linked to SDGs 10, 11 and 12 (Table 7). Overall, the pillar '*People*' is linked to twelve different SDGs, '*Planet*' with eleven, '*Prosperity*' with ten, '*Peace*' with six and '*Partnership*' with four. This pattern is explained by the first three pillars being associated with the three dimensions of sustainable development endorsed by the United Nations: social, environmental and economic; this is not the case for '*Peace*' and '*Partnership*'. The pattern is also reflected in our classification where the '*People*', '*Planet*,* and '*Prosperity*' pillars are more commonly associated with targets and SDGs (Table 7).

Aside from two notable exceptions, our classification agrees with that of other publications. We diverge, however, from previous publications for SDGs 11 and 13. For SDG 11, we do not include 'Prosperity' in our classification even though this is the pillar most often selected by organisations; at the same time, however, SDG 11 has the lowest percentage for a

'dominant' pillar. With our scoring system and target classification, 'Prosperity' is associated only with Target 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.'

The other targets include such issues as affordable housing and the upgrading of slums (11.1), public transport (11.2), participatory urbanisation (11.3), cultural and natural heritage (11.4), environmental impact and waste management (11.6) and public spaces (11.7). These issues are mostly associated with 'People' and 'Planet' according to the participants in our survey. There is no obvious explanation as to why the different publications include 'Prosperity' in their classification.

Regarding SDG 13, all organisations associated this goal exclusively with 'Planet'; however, our analysis also connects this SDG to 'People'. While it may seem obvious that climate change is linked with 'Planet', upon careful examination of Targets 13.1 (Strengthen resilience and adaptive capacity to climate-related hazards and natural disasters in all countries) and 13.3 (Improve education, awareness-raising and human and institutional capacity on climate change mitigation, adaptation, impact reduction and early warning), we

can identify the aspects of resilience, adaptation and education to climate change, elements associated with 'People' by our survey respondents. SDG 13 therefore confirms the importance of thoroughly analysing relations at the target level to properly associate SDGs to the five pillars (Villeneuve, 2016). Accordingly, our classification illustrates clearly that most SDGs are integrated across different pillars. This highlights the complexity of the SDGs when viewed from a systemic approach, a point that organisations must consider when structuring their strategic documents around the five pillars of the 2030 Agenda.

Although our classification at the target level is quite accurate, one target, out of the 126 considered, is not associated with any pillar of our SDG classification. Target 16.8 seeks to *'broaden and strengthen the participation of developing countries in the institutions of global governance.'* Survey respondents only associate this target with '*Partnership',* while SDG 16 is classified under '*People*' and '*Peace*'. Twenty-eight other targets are associated with at least one pillar from our classification and one or more pillars outside our classification. For instance, Target 3.9 (*reducing deaths and illnesses from hazardous chemicals, pollution and contamination)* is associated with '*People*' (at 48.3 per cent) and '*Planet*' (at 30.8 per cent), whereas SDG 3 is only associated with '*People*' (at 64.7 per cent and only at 9.5 per cent for '*Planet*'). Again, this supports the assumption that the target level is both more complex and more precise than the SDG level. These characteristics are extremely important for a better understanding of the nature of the system and the potential interactions within.

The analysis of the relationship between the classification of targets and the assessment of interactions also illustrates the complexity of the 2030 Agenda. Our analysis illustrates the difficulty of drawing universal conclusions and reveals the variability of possible relationships between targets. It also shows observable trends that cannot be generalised. Targets having similar classifications do not necessarily have relationships with each other, and targets having different classifications may have synergistic relationships. Even if there is an observable relationship between similarities/differences and synergies/trade-offs, there is no absolute relationship.

This notion is well illustrated in Table 6, as 84 per cent of 'indivisible' interactions (+3) are related to targets having a very strong relationship. This value lowers to 64 per cent for 'reinforcing' interactions (+2), 48 per cent for 'enabling' interactions (+1), 31 per cent for 'constraining' interactions (-1) and 36 per cent for 'counteracting' interactions (-2). The exception is the 'cancelling' interaction, where 100 per cent of identified potential linkages occur with targets having very strong relationships. Two explanations can shed light on this observation. First, the size of the sample (15) is very small compared with other assessments. As well, all interactions evaluated at -3 are from links between the three targets of SDG 13 and Targets 14.2–14.6. For links with Targets 13.1 and 13.2, the authors (International Council for Science, 2017) evaluated interactions having values between -3

to +2; however, interactions between values of -3 or -2 were used for Target 13.3. Drawing conclusions from such a small sample size is therefore rather tenuous.

Systemic approach, systemic sustainability analysis and policy coherence

The characterisation proposed in this study improves our understanding of the classification of SDGs and targets that achieve the principles of integration stated by the 2030 Agenda. As Barbier and Burgess (2017) note, 'the systems approach characterises sustainability as the maximisation of goals across environmental, economic and social systems.' While policymakers do agree on the need for a systemic approach, both the appropriation and implementation of this approach remain very modest. Although causal links are well anchored in different methods, the identification and analysis of interactions (synergies, feedback loops, trade-offs, etc.) are rarely suggested. What we are proposing in this study provides new knowledge for characterising targets, and, thus, deepen the analysis of synergies and trade-offs. Further understanding of these networks will require assessing potential feedback loops.

Allen et al. (2017) proposed an explanation for the gaps between theory and practice: 'An understandable cause could be a lack of awareness and technical capacity to apply systems analysis and integrated approaches.' Addressing this gap will require sustainable development professionals to acquire new competencies and skills. Education in system science and transdisciplinary research (Allen et al., 2017) and the capacity to analyse

sustainability from a holistic perspective (systems thinking) (Wiek et al., 2011) are key competencies required for a 'new generation and category of sustainability professionals' (Stafford-Smith et al., 2017).

The rise of needs, issues and principles implies the emergence of new approaches, such as the systemic sustainability analysis (SSA) of Villeneuve et al. (2015). SSA integrates the multiple dimensions of sustainability, the synergies and trade-offs between the goals and targets, as well as the means of implementation to achieve them. The sustainable development analytical grid (SDAG) (Villeneuve et al., 2017) is an example of a tool for applying SSA. It is based on six dimensions (ecological, social, economic, ethical, cultural and governance); dimensions that are very similar to the five pillars of the 2030 Agenda.

Regardless of which approach or tool is used, the entanglement of P-clusters, SDGs and targets, requires an ability to reveal systemic relationships between the different elements of the system and identify potential synergies and trade-offs. On that basis, an approach must also enable systems thinking within a process of policymaking and strategic change to achieve the concrete transformative results that match those of the 2030 Agenda. To improve the SSA or other methodologies—for a systemic understanding and holistic implementation of the Agenda—different actions should be applied to ensure the success of an integrated implementation of the SDGs. These actions come from good practices identified by the authors in their own engagements, and they should not be ignored in

planning and systemic analysis. These actions include i) identifying stakeholders and engaging the process that introduces system analysis; ii) defining system dynamics, identifying causality, feedback loops and the identification of potential roles for various stakeholders; iii) supporting policy, which includes engaging institutions and the training of policymakers and other stakeholders.

These actions are in line with the UN MAPS approach (United Nations Development Group, 2017) and policy coherence (Cejudo & Michel, 2015; Collste et al., 2017; Mackie et al., 2017; Nilsson et al., 2012; O'Connor et al., 2016; Organisation for Economic Co-operation and Development, 2003; United Nations Environment Programme, 2015). Policy coherence is defined by Nilsson et al. (2012) as 'an attribute of policy that systematically reduces conflicts and promotes synergies between and within different policy areas to achieve the outcomes associated with jointly agreed policy objectives.' Understanding the systemic approach and the elements of a system are therefore vital when applying such policy coherence. The results of our research may contribute to this objective by showing policymakers the importance of looking at the system as a whole when seeking greater coherence between policies, including targets clustered under the same classification.

Our results show that the study of interlinkages between SDG targets reveals much greater complexity than an articulation based merely on the wording of SDGs. All SDGs being multidimensional, it is impossible to isolate each target within a small number of pillars. For

a target to be effective and coherent, policymakers must therefore always consider the system as a whole (Nilsson et al., 2012). Contrary to what is commonly observed, they should not compartmentalise the SDGs according to any structure, such as one based on the five pillars, for instance. Assuming that SDGs 1 to 6 are well linked to '*People*,' SDGs 13 to 15 with '*Planet*,' SDGs 7 to 12 to '*Prosperity*,' and so on, implies a simplification of a complex system, an observation that is not consistent with the integrating principles of the five pillars of the 2030 Agenda. While this may help to structure and organise information for planning or accountability, this should not distract policymakers from the need to apply a systemic approach in both analysis and implementation.

There remains a lack of understanding related to the interaction of targets, an aspect that limits the scope of this study; however, no studies have evaluated the potential interactions of all 169 SDG targets. This gap limits our understanding of the entire SDG system and thus the scope of our analysis. It would also have been ideal to have a larger survey sample. As noted, the duration of the survey exercise was a barrier, in particular for uninitiated respondents. We believe, however, that the sample size was adequate for this type of study and that a larger sample would not produce markedly different results.

Our survey resulted in a large variety of responses in the association of targets to the five pillars. This diversity suggests a wide-ranging interpretation of the definitions of the pillars; these definitions are very succinct and do not include all themes covered by the SDGs.

Lastly, some respondents overinterpreted the targets, commonly associating the targets with several pillars. Although there were no correct or incorrect answers when associating the targets with the five pillars, some responses were inconsistent with the mainstream understanding of targets, while others were too difficult to explain and suggests that the respondents erred in their interpretations.

Conclusion

Our results provide new insights into various aspects of the SDGs and their targets. The classification of targets according to the five pillars of the 2030 Agenda provides an improved understanding of the complexity of SDGs, and the classification we propose is based on an original methodology that considers the multidimensional nature of the targets. The analysis of the interactions identified in the literature in relation to the classification of targets shows a nuanced correlation. The more similar the targets are in terms of classification, the more positive the interactions, as could be intuitively expected. Our analysis also reveals, however, that synergies are possible between targets of different classifications. The same logic applies to negative interactions. Our findings are useful for policymakers who must apply a systemic approach for policy coherence in sustainability analysis. They will be able to use our classification to structure their strategic documents for implementing the 2030 Agenda, to identify potential synergistic sectors and to target groups of actors, from different sectors, having interrelated issues to connect the silos.

The use of binary interactions is a good starting point for a better understanding of the SDG

system. However, it is essential to consider the nexus of interactions and the potential links

between them to understand the different subsystems and their potential synergistic or

antagonistic links. This knowledge will help develop tools and approaches for systemic

sustainability analysis, which will help lead planners to consider a systems approach when

developing policies, strategies, programmes and projects for implementing the 2030

Agenda in particular, or sustainable development in general.

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Tables

Table 1 Classifications of the 17 sustainable development goals (SDGs) in relation to the

fiver pillars (5 Ps). Each number represents a specific SDG.

Organisation	People	Planet	Prosperity	Peace	Partnership
United Nations in Viet Nam, CCA (2016)	1,2,3,4,5,6	11,12,13,14,15	7,8,9,10	16	17
United Nations in Rwanda (2016)	2,3,4	6,12,13,14,15	7,8,9,10,11	1,5,16	17
SDG Profile Report Draft, Burkina Faso (2017)[1]	1,2,3,4,5,6	12,13,14,15	7,8,9,10,11	16	
OECD (2017)[2] Azerbaijan, VNR (2017)[3] Slovenia, VNR (2017) Poland, VNR (2018) Leal Filho et al. (2018)[4] Sri Lanka, MAPS (2018)	1,2,3,4,5	6,12,13,14,15	7,8,9,10,11	16	17
Stockholm Resilience Center (2016)[5]	1,2,3,4,5,7,11, 16	6,13,14,15	8,9,10,12		17
Caribbean, MCA (2015)[6]	1,2,3,4,5,6,7	11,12,13,14,15	8,9	10,16	10,17
France Diplomatie (2017)	1,2,3,4,5	6,7,11,13,14,15	8,9,10,12	16	17
Sao Tomé e Principe, CCA (2015)	2,3,4,5,6,10,11	13,14,15	1,2,7,8,9,12	16	17
UN System Staff College	1,2,3,4,5,6,10	6,7,10,13,14,15	1,7,8,9,10,11,12	16	17
Bahamas, VNR (2018)[7]	1,2,3,4,5,6,10	6,7,9,11,12,13, 14,15	8,9,17		11,16,17
Czech Republic, VNR (2017)	1,2,3,4,5	6,12,13,14,15	7,8,9,10,11	16	16,17
Japan, VNR (2017)	1,3,4,5,8,10,12	2,3,7,12,13,14, 15	2,6,8,9,11	16	17
Lebanon, VNR (2018)	1,2,3,4,5,10	6,7,12,13,14,15	8,9,11	16	17
Morton et al. (2017)[8]	1,2,3,4,5,6	13,14,15	7,8,9,10,11,12	16	17
Niger, VNR (2018)[9]	1,2,3,4,5,6,10	2,11,12,13,15	2,7,8,9	10,11,16,17	17
Palestine VNR (2018)	1,2,3,4,5,10	6,7,12,13,14,15	8,9	11,16	17

[1] Rapid Integrated Assessment Analysis of Burkina Faso grouped the SDGs in the following categories: Human capital (People), Strong and inclusive growth (Prosperity), Environment (Planet) and Peace. Exclusion of SDG 17.

[2] The goals are presented as 'integrated and indivisible, global in nature and universally applicable.' The Agenda presents them as addressing the 5 Ps: People (broadly corresponding to Goals 1–5), Planet (6, 12, 13, 14 and 15), Prosperity (7-11), Peace (16) and Partnership (17)."

[3] SDG 1 and 5 under 'People's Dignity' category; SDG 2,3,4 under 'People' category.

[4] SDG 1 and 5 under 'Dignity' category; SDG 2,3,4 under 'People' category; SDG 16 under 'Justice' category.

[5] The Stockholm Resilience Center uses four pillars: Biosphere, Society, Economy and Partnership.

[6] Grouped into the 5 Ps and Dignity. We merged 'Dignity' and 'People'.

[7] Grouped into four pillars: Governance (Partnership), Human capital (People), Environment (Planet), Economy (Prosperity).

[8] Authors grouped Peace and Partnership together.

[9] Landlocked country, SDG 14 excluded.

Table 2 Classification of the sustainable development goal (SDG) targets

Targets	People	Planet	Prosperity	Peace	Partnership	Targets	People	Planet	Prosperity	Peace	Partnership
1.1	X					11.1	X				
1.2	X					11.2	X				
1.3	X		X			11.3	X	X			
1.4	X		X			11.4	X	X			X
1.5	X	X				11.5	X	X	X		
2.1	X					11.6		X			
2.2	X					11.7	X	X			
2.3	X		X			12.1		X			X
2.4		X	X			12.2		X			
2.5		X				12.3		X			
3.1	X					12.4		X			
3.2	X					12.5		X			
3.3	X					12.6		X	X		
3.4	X					12.7		X	X		
3.5	X					12.8	X	X			X
3.6	X					13.1	X	X			
3.7	X					13.2		X			
3.8	X					13.3	X	X			
3.9	X	X				14.1		X			
4.1	X					14.2		X			
4.2	X					14.3		X			X
4.3	X		X			14.4		X			
4.4	X		X			14.5		X			
4.5	X					14.6		X			X
4.6	X					14.7		X	X		X
4.7	X	X	X			15.1		X			
5.1	X					15.2		X			
5.2	X		X			15.3		X			
5.3	X		X			15.4		X			
5.4	X					15.5		X			
5.5	X					15.6	X	X	X		
5.6	X					15.7		X			
6.1	X					15.8		X			
6.2	X	X				15.9		X			
6.3	X	X				16.1				X	
6.4	X	X				16.2	X			X	
6.5		X			X	16.3	X			X	
6.6		X				16.4				X	
7.1	X		X			16.5				X	
7.2		X				16.6				X	X
7.3		X	X			16.7	X			X	X
8.1			X			16.8					X
8.2			X			16.9	X				
8.3			X			16.10	X			X	X
8.4		X	X			17.1			X		X
8.5	X		X			17.2					X
8.6	X		X			17.3			X		X
8.7	X			X		17.4			X		X
8.8	X					17.5			X		X
8.9			X			17.6					X
8.10			X			17.7		X	X		X
9.1	X		X			17.8			X		X
9.2			X			17.9					X
9.3			X			17.10					X
9.4		X	X			17.11			X		X
9.5			X			17.12			X		X
10.1	X		X			17.13			X		X
10.2	X		X			17.14					X
10.3	X			X		17.15					X
10.4	X		X			17.16					X
10.5			X	X	X	17.17					X
10.6			X		X	17.18					X
10.7	X			X	X	17.19					X

Table 3 Examples of Pearson correlation coefficients (PCC) for two pairs of targets having the same (1.1 and 1.2) and different (14.7 and 16.2) classifications

Target	People	Planet	Prosperity	Peace	Partnership	Total	PCC
1.1	17.84	1.35	7.17	1.26	2.34	29.96	0.998 (same 'nature')
1.2	17.34	0.85	7.84	1.43	2.51	29.97	
14.7	2.94	9.41	8.91	1.03	7.58	29.87	-0.982 (different
16.2	9.3	1.23	1.4	15.3	2.72	29.95	'nature')

Table 4 *Seven-point scale developed by Nilsson et al. (2016) and ICSU (2017)*

Interaction scoring	Name	Explanation
-3	Cancelling	Makes it impossible to reach another target
-2	Counteracting	Clashes with another target
-1	Constraining	Limits options on another target
0	Consistent	No significant positive or negative interaction
+1	Enabling	Create conditions that further another target
+2	Reinforcing	Aids achievement of another target
+3	Indivisible	Inextricably linked to the achievement of another target

Table 5 Classification of sustainable development goals (SDGs) according to the five pillars (5 Ps). Percentages represent the relative score allocated to a pillar for all targets; the exception is for targets related to the means of implementation for each SDG

| SDG	P classification
SDG 1 – No poverty	People (48.4%); Prosperity (27.1%)
SDG 2 – Zero hunger	People (40.4%); Planet (26%); Prosperity (20.8%)
SDG 3 – Good health and well-being	People (65.1%)
SDG 4 – Quality education	People (54.5%)
SDG 5 – Gender equality	People (52.4%)
SDG 6 – Clean water and sanitation	Planet (39.6%); People (30.6%)
SDG 7 – Affordable and clean energy	Planet (41.3%); Prosperity (26.4%)
SDG 8 – Decent work and economic growth	Prosperity (44.6%); People (30.9%)
SDG 9 – Industry, innovation and infrastructure	Prosperity (48.9%)
SDG 10 – Reduce inequalities	People (33.1%); Prosperity (26.8%); Partnership (19.6%); Peace (17.9%)
SDG 11 – Sustainable cities and communities	People (40.4%); Planet (24.5%)
SDG 12 – Responsible consumption and production	Planet (51%)
SDG 13 – Climate action	Planet (43.5%); People (25.4%)
SDG 14 – Life below water	Planet (57.7%)
SDG 15 – Life on land	Planet (61.6%)
SDG 16 – Peace, justice and strong institutions	Peace (43.5%); People (25.3%)
SDG 17 – Partnership for the goals	Partnership (52.9%); Prosperity (27%)

Table 6 Distributions related to categories of relationships from a Pearson correlation coefficient (PCC) being applied to target scores for the five pillars, according to the Nilsson et al. (2016) evaluation scales. For the pairs of percentage values, the percentages on the left represent the relative distribution of each interaction evaluation, while the percentages on the right represent the relative distribution in each category of a relationship linked to the PCCs. Sample (*N*) is the total for each interaction assessment (last column) and the strength of relationships (last row)

Interaction evaluation	Very weak relation	Weak relation	Strong relation	Very strong relation	*N*
	(Between -1 and -0.500)	(Between -0.499 and 0)	(Between 0 and 0.500)	(Between 0.501 and 1)	
-3	0%/0%	0%/0%	0%/0%	100%/3%	15 (1.4%)
-2	1%/3%	42%/12%	20%/9%	36%/5%	74 (7%)
-1	0%/0%	50%/22%	19%/13%	31%/6%	117 (11.1%)
1	6%/64%	28%/40%	18%/39%	48%/31%	375 (35.5%)
2	3%/33%	17%/24%	16%/34%	64%/41%	374 (35.4%)
3	0%/0%	6%/2%	10%/6%	84%/15%	101 (9.6%)
N	36 (3.4%)	263 (24.9%)	174 (16.5%)	583 (55.2%)	

Table 7 How organisations classify sustainable development goals (SDGs) according to the five pillars (5 Ps). Percentages reflect organisations that have classified an SDG (row) according to a corresponding pillar (column) or several corresponding pillars. For this reason, the sum of percentages for an SDG may exceed 100 per cent. The percentages in bold represent our classification

SDG	People	Planet	Prosperity	Peace	Partnership
SDG 1 – No poverty	**90.5%**		**9,5%**	4,8%	
SDG 2 – Zero hunger	**95.2%**	9.5%	**14.3%**		
SDG 3 – Good health and well-being	**100%**	4.8%			
SDG 4 – Quality education	**100%**				
SDG 5 – Gender equality	**95.2%**			4.8%	
SDG 6 – Clean water and sanitation	38.1%	**66.7%**	4.8%		
SDG 7 – Affordable and clean energy	9.5%	**28.6%**	**66.7%**		
SDG 8 – Decent work and economic growth	**4.8%**		**100%**		
SDG 9 – Industry, innovation and infrastructure		4.8%	**100%**		
SDG 10 – Reduce inequalities	**33.3%**	4.8%	**66.7%**	**9.5%**	**4.8%**
SDG 11 – Sustainable cities and communities	**9.5%**	**23.8%**	61.9%	9.5%	4.8%
SDG 12 – Responsible consumption and production	4.8%	**76.2%**	23.8%		
SDG 13 – Climate action	**0%**	**100%**			
SDG 14 – Life below water		**100%**			
SDG 15 – Life on land		**100%**			
SDG 16 – Peace, justice and strong institutions	**4.8%**			**90.5%**	9.5%
SDG 17 – Partnership for the goals			5%	5%	**100%**

Figure 1 Relative distribution of the 5 Ps among the 17 SDGs
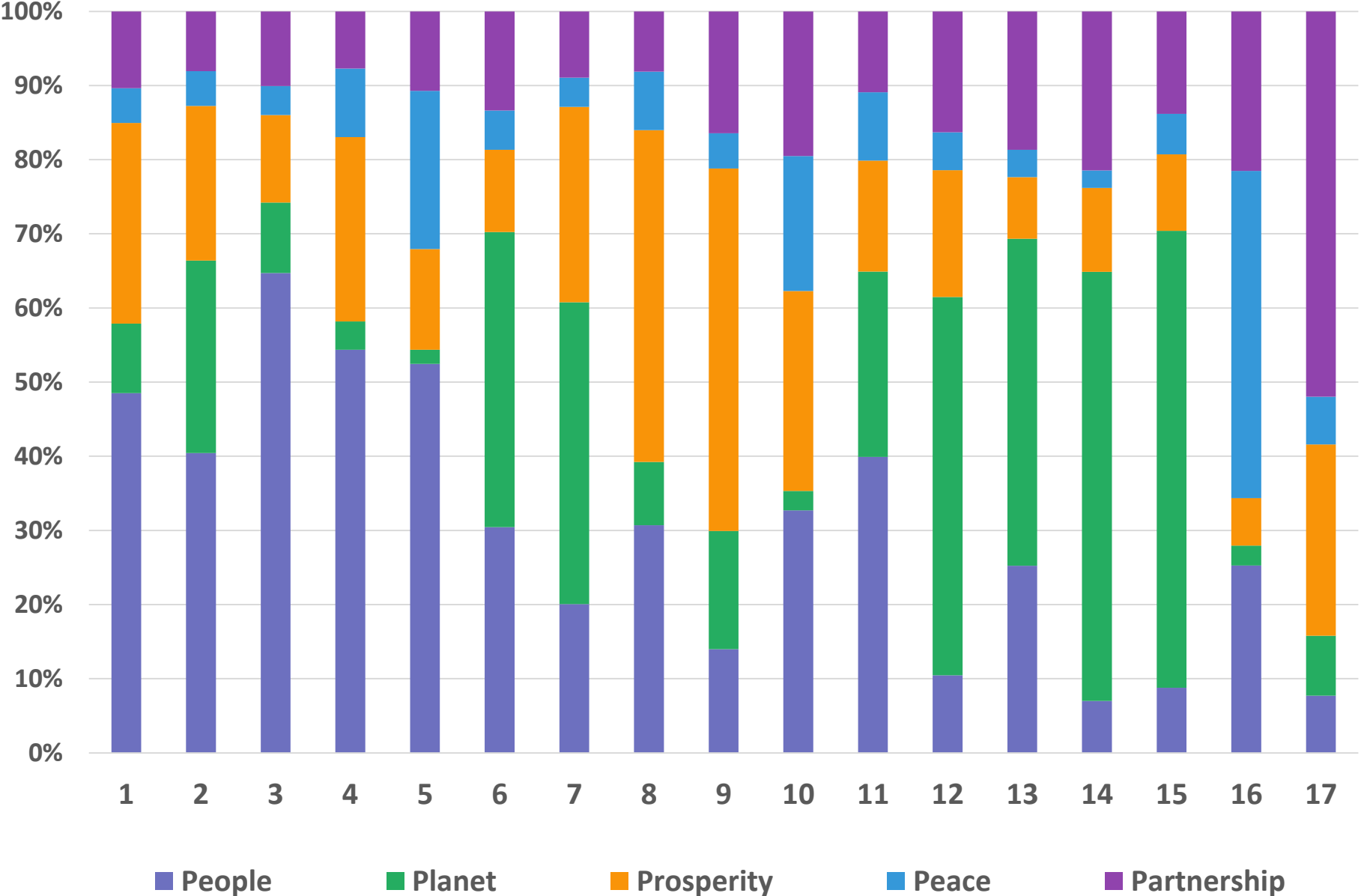
Figure 2 Linear regression between interaction assessments and Pearson correlation coefficients. Each dot represents a potential interaction identified in selected publications. $R^2 = 0.059$, $P < 0.001$