International Journal of Development and Sustainability
ISSN: 2186-8662 – www.isdsnet.com/ijds
Volume 6 Number 9 (2017): Pages 1150-1158
ISDS Article ID: IJDS17082602

Mapping the direct and indirect interlinkages across the sustainable development goals: A qualitative nexus approach

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Abstract

The United Nations sustainable development summit on 25 September 2015 led to the adoption of the 2030 Agenda for sustainable development. The adopted 2030 Agenda includes 17 sustainable development goals (SDGs) that aim to guide global action on the achievement of a common set of development objectives for the coming fifteen years. In addition to the 17 SDGs, a set of 169 sustainable development targets (SDTs) are also determined to give clear direction and objectives to achieve the SDGs. The global SDTs are directly and indirectly interlinked, which may be considered as either supportive or conflicting. There is a need to address both direct and indirect interlinkages between SDTs in order to support more coherent and effective sustainable development policy-making. This paper explores a science-informed qualitative nexus method that permits the evaluation of the direct and indirect nature of interlinkages between SDTs. A numerical experiment is presented and results are discussed.

Keywords: Sustainable Development Goals; Interlinkages; Qualitative Nexus Approach

Cite this article as: Karnib, A. (2017), "Mapping the direct and indirect interlinkages across the sustainable development goals: A qualitative nexus approach", *International Journal of Development and Sustainability*, Vol. 6 No. 9, pp. 1150-1158.

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1. Introduction

The different scopes of the sustainable development goals (SDGs) and targets (SDTs) are quantitatively and qualitatively interlinked (Georgeson et al., 2017; Karnib 2017a,b; Karnib 2016a,b; OECD 2004; Bell and Morse 2008; Meadows, 2008; UN, 2007, 2017). Actions to achieve progress in one SDT may cause underachievement or create synergies for improvements in another (Pedercini and Barney, 2010; Karnib 2017a,c,d,e, 2016a,b). Therefore, the interlinkages and integrated nature of the sustainable development agenda requires a science-based quantitative and qualitative nexus perspectives for analyzing interlinkages across the SDGs.

Interlinkages between SDTs may be considered as either supportive, conflicting or neutral. Policy-makers need to be informed, not only about the direct interlinkages between the SDTs, but also about the indirect ones. This will enable policy makers to manage synergies and/or conflicts between policies engaged to achieve the sustainable development targets in effective way.

Many studies have been developed to explore the integrated nature of the SDGs (UN Water, 2016; ICSU, 2017; UNEP, 2016; Le Blanc, 2015; Shah, 2016; Nilsson, 2017). Studies published by Le Blanc (2015), Weitz et al. (2014), UN Water (2016) and ICSU (2017) are involving informing about the direct qualitative interlinkages across SDGs, they are not engaging in analyzing the indirect interconnections. Moreover, although the quantitative nexus method proposed by Karnib (2017a) is addressing direct and indirect effects across SDGs, it is constrained by data availability of the sustainable development variables.

This study presents a qualitative nexus framework for exploring direct (explicit) and indirect (implicit) interlinkages across the SDTs. This will permit to understand better the interactions among SDGs and will assist in informing policy makers about the direct and indirect impacts of development plans engaged to achieve the sustainable development targets.

2. The proposed qualitative nexus approach for analyzing interactions at SDTs level

The SDGs aim to guide global action on the achievement of a common set of social, environmental, economic and ecosystem development objectives for the coming fifteen years. Thus, goals are the broad aims used to shape the agreed sustainable development strategies. Specific sustainable development targets are determined to give clear objectives to achieve the SDGs.

The direct interlinkage relations between SDTs can be modelled as a matrix of direct interconnections, in which each element representing the effects of achievement of the row component, on the achievement of column component. These effects may be positive interactions (supportive), negative interactions (conflicting) or neutral. Many examples of the different categories of direct interconnections among various SDTs can be found in UN Water (2016), ICSU (2017) and Karnib (2016b). Additionally, each element of the matrix will receive a set of indirect effects based on the direct interconnection information represented in the matrix of the direct interlinkages, which will form a three dimensional matrix of direct and indirect interconnections as shown in Figure 1.

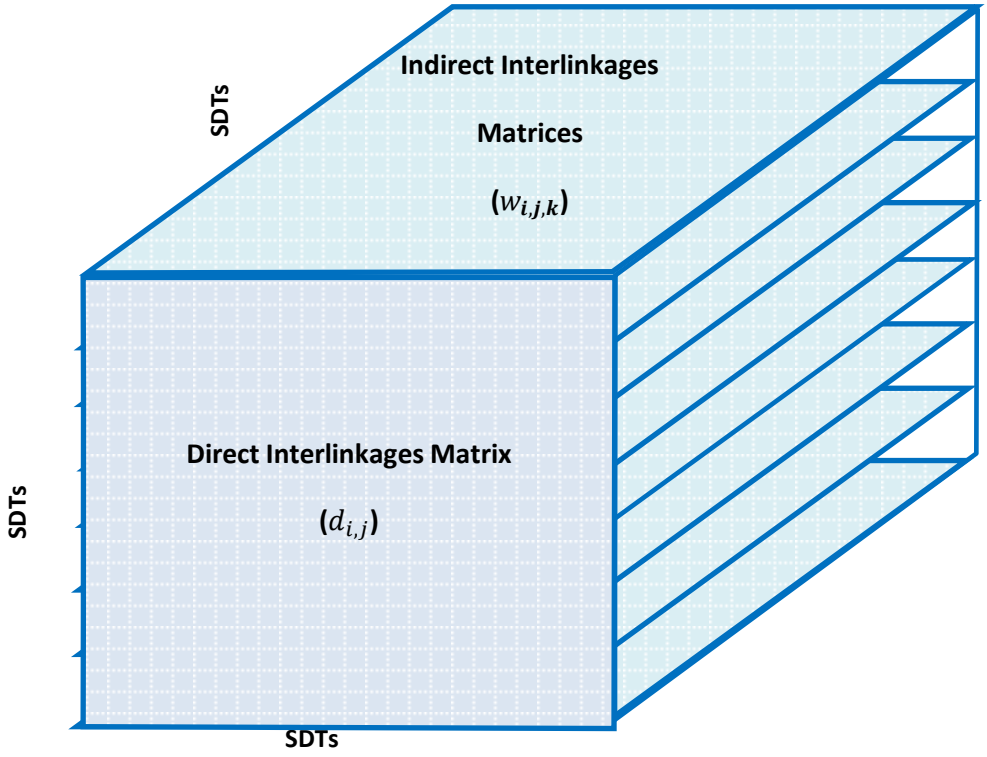

Figure 1. The 3-dimensional matrix of direct and indirect interlinkage relations of Sustainable Development Targets (SDTs)

This study introduces a method to evaluate the qualitative indirect interlinkages based on the information including in the matrix of direct interlinkages. The proposed framework is based on identifying three categories of qualitative causal relations underlying progress or achievement of goals and targets. Positive interactions (supportive) and interactions characterised by trade-offs (conflicting) are scored with 1 and -1 respectively. For SDTs revealing no significant positive or negative interactions, a score of 0 (neutral) is assigned.

2.1. Evaluation of the direct interactions

Let the SDTs direct interlinkages matrix be *D* and its elements be d_{ij}. If we denote by:

$d_{i,j}$: the direct interlinkage relationship of the i^{th} SDT and j^{th} SDT;

The three identified categories of qualitative causal relations underlying achievement or progress of targets will be scored 1, -1 and 0 as follows:

$d_{i,j}$ = 1: a supportive relationship where the achievement of i^{th} SDT creates positive conditions that lead to the achievement of j^{th} SDT;

$d_{i,j}$ = 0: a neutral relationship where the pursuit of i^{th} SDT does not significantly interact with the j^{th} SDT.

$d_{i,j}$ = -1: a conflicting relationship where the pursuit of of i^{th} SDT counteracts the achievement of j^{th} SDT.

2.2. Evaluation of the indirect interactions

If we denote by $w_{i,j,k}$ the indirect interlinkage relationship of the i^{th} SDT and j^{th} SDT via the k^{th} SDT. Then, the indirect interconnections could be evaluated based on the values of the direct interlinkages as follows (Table 1):

Table 1. Method of evaluation of indirect is based on the values of the direct interlinkages

If	Then
$d_{i,k}$ = 1 (supportive) and $d_{k,j}$ = 1 (supportive)	$w_{i,j,k}$ = 1 (supportive)
$d_{i,k}$ = 0 (neutral) and $d_{k,j}$ = 1 (supportive)	$w_{i,j,k}$ = 0 (neutral)
$d_{i,k}$ = 1 (supportive) and $d_{k,j}$ = -1 (conflicting)	$w_{i,j,k}$ = 0 (neutral)
$d_{i,k}$ = -1 (conflicting) and $d_{k,j}$ = -1 (conflicting)	$w_{i,j,k}$ = -1 (conflicting)
$d_{i,k}$ = 0 (neutral) and $d_{k,j}$ = -1 (conflicting)	$w_{i,j,k}$ = 0 (neutral)
$d_{i,k}$ = 0 (neutral) and $d_{k,j}$ = 0 (neutral)	$w_{i,j,k}$ = 0 (neutral)

In contrast to previous approaches that study direct patterns of dependencies, recognizing potential indirect patterns, that became possible using the proposed method, will be useful in informing policy makers about the potential synergies and/or conflicts between policies engaged to achieve sustainable development targets.

It is important to mention that the evaluation of the indirect relations is limited to the first-order only, the evaluation of higher-order indirect relations is possible but it is restrained by the computational and interpretation complexities of the combined effects.

3. Illustrative example and analysis of results

In order to put the proposed method in practice, the SDTs shown in Table 2 will be considered. SDTs 2.1, 2.3, 2.4, 6.1, 6.2, 6.3, 6.4, 6.6, 7.1, 7.2, and 7.3 are interconnected and they are related to the water, energy and food goals of the 2030 Agenda. Therefore, the analysis of qualitative interlinkage relations across these SDTs fall within the water-energy-food nexus perspective.

It is important to mention that the nature of these interactions are in some way context-specific and depend on particular policy options engaged to achieve the SDGs. Presenting an exhaustive mapping of the potential direct interconnections is beyond the scope of this study which particularly aims to present qualitative method to evaluate the indirect interlinkage information based on the direct relations.

Using the proposed method, the indirect interlinkages of targets 2.3 (Food/Agriculture productivity), 6.1 (Water supply) and 7.2 (Renewable energy) are evaluated based on the direct interconnection relations of the above mentioned targets. The proposed direct interlinkage relations matrix across the above mentioned SDTs are presented in Table 3.

The following direct and indirect interlinkages information are resulted as shown in Figure 2:

For target 2.3: There are direct supportive links from target 2.3 (food/agriculture productivity) to targets 2.1 (end hunger), 2.4 (sustainable food production) and 7.2 (renewable energy, i.e., increasing food/agriculture productivity may enable the increase of renewable energy in the overall energy set via biofuel production). Moreover, the indirect interlinkages from target 2.3 to target 2.1 are supportive via targets 2.4 and 7.2. In fact, target 2.3 is directly supportive to target 2.4, and target 2.4 is directly supportive to target 2.1, therefore, target 2.3 is indirectly supportive to target 2.1 via target 2.4.

Table 2. The considered SDTs

SDG Number	SDG Theme	SDT Number	SDT Aim
2	Food/ Agriculture	2.1	By 2030, end hunger and ensure access by all people, in particular the poor and people in vulnerable situations, including infants, to safe, nutritious and sufficient food all year round
		2.3	By 2030, double the agricultural productivity and incomes of small-scale food producers, in particular women, indigenous peoples, family farmers, pastoralists and fishers, including through secure and equal access to land, other productive resources and inputs, knowledge, financial services, markets and opportunities for value addition and non-farm employment
		2.4	By 2030, ensure sustainable food production systems and implement resilient agricultural practices that increase productivity and production, that help maintain ecosystems, that strengthen capacity for adaptation to climate change, extreme weather, drought, flooding and other disasters and that progressively improve land and soil quality
6	Water	6.1	By 2030, achieve universal and equitable access to safe and affordable drinking water for all
		6.2	By 2030, achieve access to adequate and equitable sanitation and hygiene for all, and end open defecation, paying special attention to the needs of women and girls and those in vulnerable situations
		6.3	By 2030, improve water quality by reducing pollution, eliminating dumping and minimizing release of hazardous chemicals and materials, halving the proportion of untreated wastewater, and substantially increasing recycling and safe reuse globally
		6.4	By 2030, substantially increase water-use efficiency across all sectors and ensure sustainable withdrawals and supply of freshwater to address water scarcity, and substantially reduce the number of people suffering from water scarcity
		6.6	By 2020, protect and restore water-related ecosystems, including mountains, forests, wetlands, rivers, aquifers and lakes
7	Energy	7.1	By 2030, ensure universal access to affordable, reliable and modern energy services
		7.2	By 2030, increase substantially the share of renewable energy in the global energy mix
		7.3	By 2030, double the global rate of improvement in energy efficiency

Similarly, target 2.3 is directly supportive to target 7.2, and target 7.2 is directly supportive to target 2.1, thus, target 2.3 is indirectly supportive to target 2.1 via target 7.2. On the other hand, while the direct interlinkage from target 2.3 (food/agriculture productivity) to target 7.2 (renewable energy) is supportive, there is indirect conflicting link from target 2.3 to target 7.2 via target 6.1 (water supply). In fact, there is direct conflicting link from target 2.3 to target 6.1, i.e., intensive conventional agriculture can in some cases counteract the access to safe drinking water where competition over water can result in trade-offs; and there is direct conflicting link from target 6.1 to target 7.2, i.e., increased utilization of unconventional water supply options (e.g. desalination) to satisfy growing demand for freshwater supply could constrain renewable energy deployment due to the high energy use of these options; therefore, the indirect link from target 2.3 to target 7.2 via target 6.1 is conflicting.

Table 3. The direct interlinkage relations matrix across the considered SDTs

	2.1	**2.3**	**2.4**	**6.1**	**6.2**	**6.3**	**6.4**	**6.6**	**7.1**	**7.2**	**7.3**
2.1		0	0	0	0	0	0	0	0	-1	0
2.3	1		1	-1	0	0	-1	-1	0	1	0
2.4	1	1		0	0	1	0	1	0	0	0
6.1	1	0	0		1	0	1	0	0	-1	0
6.2	1	0	0	1		1	1	1	0	1	0
6.3	1	1	1	1	1		1	1	0	1	0
6.4	1	1	1	1	1	0		1	0	1	0
6.6	0	0	0	0	0	0	0		0	0	0
7.1	1	1	0	0	0	0	0	0		0	0
7.2	1	1	1	1	0	0	1	1	1		0
7.3	1	1	1	1	0	0	1	1	1	1	

Source: Compiled by the author

Not Applicable

For target 6.1: There are many indirect supportive interconnections across the SDTs via targets 6.2 (sanitation) and 6.4 (water use efficiency). Moreover, although the direct interlinkage from target 6.1 (water supply) to target 7.2 (renewable energy) is conflicting, there is indirect supportive interlinkage from target 6.1 to target 7.2 via targets 6.2 (sanitation) and 6.4 (water use efficiency).

For target 7.2: Even though the direct interlinkage from target 7.2 (renewable energy) to target 7.1 (access to energy) is supportive, there is no indirect interlinkage between these two targets.

As the indirect interlinkage information have been evaluated for the considered targets, interlinkages that are not yet recognized are now available using the proposed method to inform policy making.

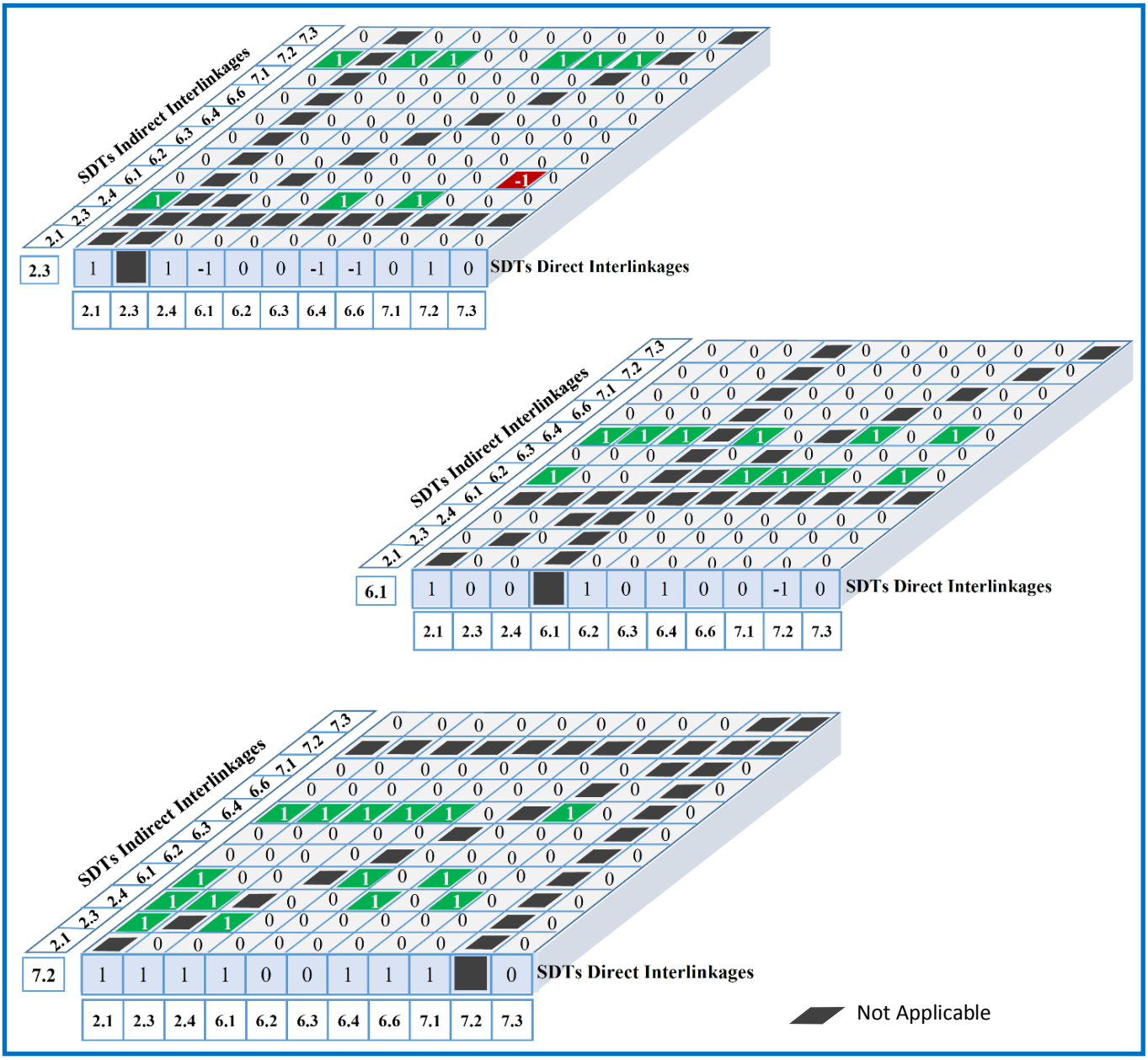

Figure 2. The direct and indirect interconnections of targets 2.3, 6.1 and 7.2 framed as 3-dimensional interlinkage matrix

4. Conclusions and further developments

Global sustainable development goals are directly and indirectly connected to each other. Informing policy makers about synergies and trade-offs among policies engaged to achieve the SDGs necessitates science-based nexus tools that permit the evaluation of the direct and indirect interlinkage relations.

This paper introduces a qualitative nexus approach to evaluate the interconnections of the global sustainable development targets (SDTs) that directly and indirectly affect one another. The proposed method allows the evaluation of the effects of the indirect interconnections by diffusion the direct qualitative interlinkage relations among the SDTs. This method informs about the direct and indirect consequences that affect the achievement of the sustainable development targets and goals. The key strength of the approach is that it generates science-informed analysis of the interactions across SDTs and SDGs by deepening the understanding of direct and indirect qualitative interactions where quantitative interactions based methods could not be easily applied due to lack of data availability.

This study is limited to evaluation of indirect relations of first-order only, the evaluation of higher-order indirect relations is possible but it may limit the interpretation of the combined effects.

The present study is based on using three interaction relations: i) supportive, ii) conflicting and iii) neutral. To explore more realistic prospects, the undergoing development of this study explores the evaluation of direct and indirect interlinkage relations that will cover eleven-point scale of interactions (five-point scales for each of the supportive and conflicting interactions plus one for the neutral). Moreover, in order to facilitate interactions interpretation, the undergoing developed method will also provide one aggregated indirect score for each direct link.

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