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Manuscript title: Assessing the Impact of Infrastructure Projects on Global Sustainable Development Goals

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Abstract

While sustainability of civil infrastructure is critical to professionals, project owners, regulators, funding agencies and the public, little is done to link individual project sustainability to the United Nation's 17 global sustainable development goals for 2030. This paper provides some answers but also exposes many questions that need resolution by the infrastructure sector. Using empirical evidence, the authors have identified a 'golden thread' between best-practice sustainability-reporting frameworks at project level with those at organisational level. In doing so, they find there is sufficient linkage to embed sustainable-development-goal impact targets into the design stage of an infrastructure project. This would provide a more robust investment appraisal at the project design phase, helping to define project success more widely across the triple bottom line of economic, social and environmental outcomes and associated impact.

1. Introduction

There is now only a decade to achieve the global goals for 2030 that were detailed in the United Nations' (UN) *Transforming Our World* report (UN, 2015), which was adopted by 193 states at the UN general assembly in 2015. This has provided a globally agreed sustainable development framework consisting of 17 sustainable development goals (SDG) (**Error! Reference source not found.**) and 169 targets to be achieved by 2030. But progress towards the targets is perilously slow (OECD, 2019; UNs, 2019 Sachs *et al.*, 2017). While there have been some significant advances since the Rio summit (1992 and +20 in 2012) and the Kyoto protocol (2005), such as the transformational technologies for battery-powered cars and renewable energy, even a rise of 1.5ºC now appears to be inevitable (UN IPCC, 2018). This temperature rise would potentially wipe out almost all of the world's coral with hundreds of millions of people potentially killed from the effects of drought (UN IPCC, 2018) and coastal flooding, while the threat of starvation will likely trigger unprecedented mass migration. These are the macro level reasons for immediate, unified and impactful action.

However, for civil engineers to take action on their projects, they need to be provided the practical tools, the processes and the leadership to turn bold statements of intent into viable engineering solutions. The challenge of linking infrastructure project sustainability performance to SDG targets is problematic as a recent Institution of Civil Engineers' survey (Mansell, 2018) demonstrated: while the appetite for SDG reporting at project level is very strong (87%), especially by millennials, only a third of the 325 respondents to that survey assessed current tools as 'fit for purpose'. They identified four primary challenges to closing

the gap: inherent difficulty in measuring project success using poorly understood output/outcome definitions; competing business priorities; a lack of leadership; and the lack of suitable tools, methods and frameworks to carry out meaningful measurement of SDG success at the project level. This represents a knowledge gap that results in weaker investment decisions since SDG lessons are not being learned from project delivery success and failures.

The problem is complex and multi-faceted in nature, at both the project and organisational levels. At the organisational level, there is a plethora of financial and non-financial reporting artefacts (such as rules, regulations and advisory guidance) that compete for adherence and conformity, which is exacerbated at project level, where there is largely an absence of guidance and legal frameworks to support consistent reporting. This results in ad hoc reporting that, done well, provides transformative capability to both the shareholders and wider stakeholders, while done badly it erodes stakeholder's confidence that society is maximising the benefits from finite levels of investment. It is not just a question of the return on investment, it is also a matter of finite time – sand is passing rapidly through the hourglass.

2. Sustainable development and sustainability reporting

Sustainability is problematic, both in definition and in practice. It variously embodies views that place it at the core of everything we do in the infrastructure world, and at the opposite end of the spectrum, there are those that give lip-service to it since it is not perceived as value-adding. Realities are that sourcing data is too complex and takes too much time and perhaps more fundamentally, is the uncertainty in the definition of project 'value', 'impact' and

'success'. Most executives are aware of the challenges whilst understanding that sustainable development is good for business. It achieves efficient use of resources with environmental, social and business benefits and uses the public reporting of their alignment to sustainable principles and achievements to further their corporate reputations and build public confidence in their stock. It also has the benefit of attracting environmentally aware millennials in an increasingly competitive recruitment market.

Before examining how the SDG success of projects can be measured, there is a need to understand why this is important and how sustainable development has evolved into a 'three-legged stool' that needs to balance economic, social and environmental priorities; what some call: people, profit and planet (Elkington, 1994). Helpfully for project managers seeking ways to measure SDG impact, the Association of Project Management's Body of Knowledge (APM BoK, 2012) provides useful insights into how clarity can be achieved through its definition of sustainability as *'*an environmental, social and economically integrated approach to development that meets present needs without compromising the environment for future generations*'*.

The APM's definition has been based on the modern concept of sustainable development as derived from the Brundtland Report (Brundtland et al, 1987), which suggests that efforts to create improvements in the short-term should be without a negative impact in the longer-term. It also recognises that project strategies need to consider success against the triple bottom line (TBL) of social, environmental (or ecological) and economic (or financial) effects, or otherwise noted as the 'three pillars' concept of 'people, profit and the planet' (Elkington, 1994,

2013, 2018; Griggs *et al.*, 2013).

Critical to TBL is the understanding that sustainable development is only achieved when there is balance or a trade-off between these three aspects as shown in ***Error! Reference source not found.*** below. This shows the development of the concept by Johan Rockström (2016) that proposes a new way of viewing the economic, social and ecological aspects of the SDGs, which implies that economies and societies are seen as embedded parts of the biosphere. The greater number of SDGs aligned with the social layer should not imply that this is more important, instead, the diagram suggests that we should transition toward a logic where the economy (profit) serves society (people) so that it evolves within the safe operating space of the environment (planet) (Elkington, 1994 & 2018; Griggs *et al.*, 2013).

3. Building an infrastructure transformation model

This paper follows-on from the companion journal article (International Journal of Sustainable Engineering, awaiting review) that proposed a new SDG project transformation process model for the infrastructure sector. It provides the 'lens', called the SDG infrastructure impact-value chain (IVC), to analyse whether there is evidence of a 'golden thread' between best practice sustainability reporting frameworks at project level, with those at organisational level. Given the objectives of the research, the following hypothesis was formulated: the proposed IVC transformation model provides a 'golden thread' linking sustainability frameworks at project and organisational levels with SDG impacts. The IVC model (**Error! Reference source not found.**) is based on four underpinning theoretical models including:

1) Theory of change (Weiss, 1995; Stein and Valters, 2012);

2) Creating shared value (Porter, 1985 & 2011; Mansell, 2019a);

3) Infrastructure systems approach (Hall *et al.*, 2016; Thacker and Hall, 2018); and,

4) Triple bottom line (TBL) (Elkington, 1994, 2013, 2018; Griggs et al, 2013).

The last of these, the TBL, provided the link to SDGs through a more holistic 'systems approach' to address infrastructure sustainability in the SDG context. It also builds on evolving knowledge on impact definition, which when applied to the concepts of Michael Porter's 'value chain' and 'creating shared value', allows a clearer understanding of the so called 'ends, ways, means' process of investments, from input of capital, through to the delivery of activities and outputs, that produce outcomes, which in turn, can be mapped to SDG impacts. The IVC provides a new holistic method to improve sustainability on projects and programmes by guiding decision-makers in their investment choices through confidence that they link to specific SDG targets.

3.1 Hierarchy/levels between project-organisation to global goals

When considering sustainability and SDG reporting at project level (Mansell, 2019b), there are two core questions that have SDG related impacts: 1) In project delivery, how does the design and construction of the project impact on the societal and environmental status quo (e.g. what is the impact on air and water quality during construction)?; and 2) What does the completed project do for the community (e.g. by how much does the waste water treatment plant improve sanitation)? These two parts are core to understanding the measurement of sustainable development at project and SDG levels, as shown in **Error! Reference source not found.**

below. The first question is focused on the delivery phases and is tactical in nature, while the second seeks to define the longer-term outcomes and impacts, that are more strategic in orientation.

A further dimension that aids understanding of SDG impacts on infrastructure projects is the hierarchy, or levels, of SDG reporting as shown in **Error! Reference source not found.**.

The diagrams in **Error! Reference source not found.** and **Error! Reference source not found.** highlight three issues: there are two core perspectives at the project level – during project delivery and post-delivery (the linear relationship shown at the lowest point of the cascade); there are different reporting requirements at each of the levels (depicted by the numbers 1−3 in **Error! Reference source not found.**) from global/national targets, down to project level targets; and the targets at each level are dependent on the context of the social, political, economic and type of national economic infrastructure category.

In practice, the golden thread shown in **Error! Reference source not found.** could be used to map the TBL against the five stages of the IVC as shown in Table 1. The examples shown indicate that there are clear 'theory of change' patterns that have also been clearly established in case study work on Anglian Water's SDG adoption (Mansell, 2019c). This shows that the theory of change linear connectivity can be linked directly to project and organisational level understanding of sustainability reporting. This is the conceptual basis for proposing that there is a golden thread. The next section provides the evidence to underpin this assertion.

4. Methodology: testing for the 'golden thread'

In the search for a 'golden thread' between ground-level project delivery and the strategic level

Global Goals (i.e. the research hypothesis), two tests at the two different levels were conducted. Test 1 analysed whether there is a consistent approach to measuring sustainability across the project-level Ceequal (BRE, 2019) method and the organisational-level GRI approach (GRI, 2019). Test 2 explored whether Ceequal could be mapped to SDG global level goals. If these tests proved positive, then there would be evidence to support the measurement of SDG at project and organisational levels. The logic-based flow of the tests is shown in **Error! Reference source not found.**.

4.1 Identifying the sustainability tools as the 'reference class' for analysis

The focus of the investigation was on the detailed analysis of existing sustainability reporting methods across two of the hierarchy levels, i.e. at the project and organisational levels. Whilst there are literally hundreds of sustainability methods used globally, from simple spreadsheet-based approaches to enterprise wide, cloud-based systems, the selection of the two methods was based on meeting four criteria: (1) **extent of uptake** based on the percentage of use; (2) **recognition** by reporting authorities, including having government endorsement; (3) **currency**, with the latest updates reflecting 2018-2019 changes in legal and advisory frameworks; and, (4) **accessibility** of data sets to enable detailed analysis. Based on these criteria the research team identified Ceequal (BRE, 2019) as the leading international sustainability reporting method for infrastructure at the project level. It also identified the Global Reporting Initiative's (GRI) Standard (2019) as the most frequently used reporting tool at the organisational level. Indeed, from the world's largest 250 corporations, 92% report on their sustainability performance and 74% of these use GRI's Standards to do so, with 23,000

corporate sustainability reports currently in the GRI database (Global Reporting Initiative, 2019). Both of these methods are described in more detail below.

4.1.1 Project-level selection of sustainability assessment technique

Thirteen sustainability assessment methods were examined, including the following: Ceequal (BRE, 2019); Breeam (BRE, 2019); Halstar (Pearce *et al.*, 2012); Spear (McGregor and Roberts, 2003); ASPIRE (Siew et al, 2013); ISO14001 (ISO, 2019); OHSAS 45001 (ISO, 2019); Jacobs Value (Gasparatos, 2010); LEED (Awadh, 2017); Envision Rating system by ISI and Harvard University (Shivakumar *et al.*, 2014); IS Rating Scheme by Infrastructure Sustainability Council of Australia (ISCA, 2019); Infrastructure Voluntary Evaluation Sustainability Tool (Invest) (Clevenger *et al.*, 2013); SuRe® Standard for Sustainable and Resilient Infrastructure (Butler et al, 2014); and, Sustainable Transportation Appraisal Rating System framework (Stars) (Sakamoto, 2014). These frameworks were assessed against the selection criteria set out above and Ceequal scored the highest and was adopted within the research. Ceequal was the first evidence-based sustainability assessment, rating and awards scheme for civil engineering. It is less ‘stick’ and more ‘carrot’ to support a positive learning environment through structured discussions and performance management of sustainability issues. The Ceequal method provides a rigorous and comprehensive sustainability assessment and rating approach that supports clients, designers and contractors to improve the specification, design and construction of infrastructure.

4.1.2 Organisational-level selection of sustainability assessment technique

Seven sustainability approaches were considered at the organisational level: Global Reporting Initiative (GRI, 2019); UN Global Compact (2019); Carbon Disclosure Project (Matisoff *et al.*, 2013); GHG Protocol (Barrett *et al.*, 2013); OECD Guidelines (Barkemeyer *et al.*, 2014); Integrated Reporting (De Villiers *et al.*, 2014). Based on the selection criteria and analysis by the industry leaders (Corporate Reporting Dialogue, 2019; PwC SDG Reporting Challenge, 2018), GRI scored highest amongst the global methods analysed, particularly on acceptance and recognition criteria. For example, it was used by 6,671 organisations in 2017 (GRI database, 2019) and 75% of Fortune 250 companies (KPMG, 2017) across 91 countries.

4.2 Selection of methods for each of the tests

Two tests were developed to address the research hypothesis. These required a variety of analytical methods, which are discussed below. Full analytical charts and data records can be accessed from the authors since there is limited space and consequently only high-level summaries are included in this paper. The methods chosen reflected the different nature of the two sustainability reporting tools. Both are voluntary, allow selective use of areas that are self-assessed as relevant to the project/business and have an embedded management process that encourages dialogue with stakeholders. Most importantly, they both champion the fundamental principles of effective governance (OECD, 2011) of accountability, responsibility, transparency and fairness (Muller, 2017). However, despite these similarities, there are some fundamental differences, which are shown in Table 2.

4.3 Does Ceequal map to GRI across the IVC thematic areas?

The first technique applied was the use of a high-level matrix mapping technique that compared the Ceequal Categories with GRI Materiality Topics. The second method used was a text mining/analysis technique to identify intertextual patterns (Foucault, 1973) of significance. Both of these methods used the IVC framework to structure and prioritise the topics of value for analysis.

4.3.1 High level analytical matrix mapping of linkage to TBL

The method for building high-level associations between Ceequal Categories with GRI Materiality Topics was a simplified version of the 'ecosystem service matrix' (Jacobs *et al.*, 2015; Burkhard *et al.*, 2012). This approach builds a tabular format to test strength of linkages across two dimensions and then subsequently uses expert groups to test the strength of the connection points. This part of the test was limited to input from the authors and thus the involvement of more experts would have been required to further stabilise the findings. However, the technique was aimed at constructing an initial composite measure, such as identifying key indicator words and primary 'hot spots' across the samples that could be used in the second phase of Test One.

4.3.2 Detailed text mining-analysis to establish IVC links between Ceequal and GRI

The chosen method for detailed analysis was Text Mining-Analysis. With the advances of software solutions, Text Mining is used as a methodology for social scientists to support text analysis because it offers the ability to manage and quantify huge amounts of data in a very short time. It is used across academic disciplines such as economics (Levenberg at al., 2014),

political science (Grimmer and Stewart, 2013) and sociology (Mische, 2014). The specific technique used for this study was Named Entity Recognition which provides a statistical technique to capture key 'indicator' words as part of the content analysis (Krippendorff, 2018). This requires a coding frame that was built on the IVC four core concepts. An advanced technique of comparing key words between texts was first defined by the philosopher and historian Foucault (1973) who identified the intertextual patterns that can determine answers to social science questions. In order to identify intertextual patterns, text mining requires a hierarchy model, or 'tree map' that in this case used the IVC framework to link nodes of key information, with sub-nodes and specific words that are associated with the four IVC concepts. For example, the first concept is based on the Theory of Change that has a linear progression linking inputs, through activities and outputs, to outcomes and impacts. These are shown in the top part of the relationship chart, with the inclusion of benefits and value as additional words of high interest.

The tree map in **Error! Reference source not found.** illustrates 6 primary nodes, the 13 sub nodes and 42 Key Indicator Words. The analysis of the words was enabled by a specialist software tool, NVivo, which is a qualitative data analysis software package that enables rapid analysis of large quantities of data. The tool was used to provide detailed text analysis of the prioritised Key Indicator Words as shown in **Error! Reference source not found.**, across the two publications in Table 3.

Using these techniques, it was anticipated that the research in Test One would provide evidence as to whether the Transformation Process Model, using the IVC concepts, enabled a

way to find a ‘golden thread’ from project to organisational levels. Test Two was aimed at providing the means to extend the linkage all the way through to the SDG Impacts.

5. Results and discussion

In the search for a 'golden thread' between bottom-up project delivery and the strategic level of the Global Goals, four related theoretical models were used. This provided a framework for two tests, each of which had two parts. The results are captured below.

5.1 Test 1. Does Ceequal map to GRI across the IVC thematics?

5.1.1 Part one of test 1

Through the use of the high-level analytical matrix mapping, it was confirmed that there are verifiable linkages between the Ceequal categories with GRI materiality topics. This approach builds a tabular structure (**Error! Reference source not found.**) that is captured in bar chart format (**Error! Reference source not found.**) to show the level of connectivity across the three TBL areas of Economic, Social, and Environment.

The data in **Error! Reference source not found.** shows that the Ceequal categories (y axis) has strong correlation with GRI standards' (x axis) thematic topics of management (GRI 101), environment (GRI 300) and to a lesser degree, there is reasonably strong mapping in 40% of the GRI materiality topics in economic (GRI 200) and social (GRI 400) areas, as shown below.

The results identify the following key findings:

- The three areas of TBL do link across from Ceequal to GRI, although they are only implicit in Ceequal, whereas for GRI, the labelling is explicit.
- There are sufficient linkages to give confidence of a credible basis to assume that project

level sustainability reporting using Ceequal, could be grouped under similar TBL categories to GRI, which would help organisations align sustainability reporting. It also provides the first half of the 'golden thread'.

- The evidence is subjective (since it is based on the authors' views) and needs further development to further strengthen the stability of the findings. This is done in part 2 of this test, using text analysis techniques.

5.1.2 Part two of test 1 − detailed text mining-analysis to establish IVC links between Ceequal and GRI

The chosen method for detailed analysis was Text Mining-Analysis, using the qualitative analysis NVivo software tool (Bazeley and Jackson, 2013). The test analysed Key Indicator Words that relate to IVC's four concepts (**Error! Reference source not found.**) across Ceequal and GRI.

It should be noted that the percentage figures in the two columns in Table 4, that are titled '% for document', represent how many times the key indicator word appeared in the relevant document as a percentage of the total words (only counting the words of 3 and above letters). It was a coincidence that the GRI total words came close to 100,000 words, thereby giving a metric correlation. For example, the key word 'impact', which is part of the 'Ends IVC' sub-node group, had 976 appearances in the GRI document which neatly represents 0.97%, (representing nearly 1 in every 100 words of 3 letters and above, therefore highly relevant), and 267 (0.55%) in the Ceequal document, representing about 1 in 200 words. The summary of the table is shown below:

The results shown in Table 5 below and **Error! Reference source not found.** above, illustrate the percentage of occurrences of each key indicator word across the documents which has allowed results to be interpreted and a possible link from project-to-organisational level sustainability reporting to be assessed. Using the example given above on the analysis of the 'impact' key word, it implies that there is more emphasis on the post-project impacts in the GRI, but caution should be applied to linear linguistic comparisons because there are subtleties that need to be considered, (noting that a key issue influencing the findings is that Ceequal is largely project orientated and that GRI is organisational focused) such as:

- Ceequal does not explicitly refer to economic issues as frequently as GRI but implicitly considers economic benefits from approaching sustainability from an efficiency and effectiveness perspective.
- Ceequal has less use of the word 'social' but places more of an emphasis on social issues through reference to stakeholders and communities. As a result, these should be seen as synonymous.
- Ceequal uses language specific to the engineering and infrastructure sector, whereas GRI uses generic language due to it being for all sectors.
- Ceequal is more detailed in its language, reflecting the tactical nature of its projects' activities and outputs. It is apparent that Ceequal does not use the language of outcomes and benefits, but instead, partly covers for this by use of 'impact' but used in a different sense to the IVC definition.

The main findings from the analysis are captured in Table 5 below, with the

corresponding recommendations indicated in bold '**R**', which are summarised in the table below.

5.1.3 Emerging issues from test 1 (parts 1&2)

The research appears to indicate that there is supporting evidence of a golden thread, across all of the TBL lines, as shown in **Error! Reference source not found.**. The data in the tree map highlights that on the left originating side, there is an average of 0.3% use of the 42 key indicator words (see **Error! Reference source not found.**) across the two core documents (Table 3). The diagram (**Error! Reference source not found.**) shows the quantitative data that indicates six main similarities and differences between the two methodologies, which are as follows:

- There are specific areas of verifiable linkages between Ceequal Categories with GRI Materiality Topics, as well as gaps. The linkages suggest a verifiable golden thread;
- Ceequal's project-level sustainability reporting places more emphasis on environmental issues and social issues;
- Economic issues are addressed at half the frequency at project level than at organisational level, which suggests that other economic tools, often related to the business cases, are being used at project level and also, that economic criteria are implicitly embedded in the efficiency of the management processes that address the sustainability questions;
- The 'SDG' key indicator word is not used which is partly explained because SDGs are a relatively new concept and sustainability reporting frameworks have been developed over many years and take years to change, but this potentially delays the ability of

making explicit linkages from projects through to SDG targets;

- The Ceequal reporting approach has a significant focus on assessment and verification of evidence to encourage the client/contractor/designer to have the right sustainability discussions on the right issues, early enough to impact the efficiency and effectiveness of the project's sustainability footprint. Thus Ceequal is proactive. GRI is more reflective in approach, capturing sustainability achievements and actions against the TBL themes in their annual reports;
- Both are intended to be voluntary and rely on the 'carrot' of highlighting good performers, instead of the 'stick' of reputational or fiscal penalties.

5.1.4 Recommendations from test 1 (parts 1&2 – see Table 5)

1. Different tools are needed for different project and organisational levels. A suite of tools enables the optimal performance level of sustainability measurement specific to both the project level and organisational level. However, a golden thread runs through all levels, based on the TBL, which provides a route from tactical level project delivery to strategic SDG impacts.
2. While recognising that the two approaches are focused at different levels, there is an opportunity to strengthen SDG coherence in future versions by increasing use of IVC terminology, especially the terms of: 'outcomes' and 'impact', that relate to the second part of **Error! Reference source not found.**. This could be supported by the ICE providing learning and development (L&D) education of the IVC theoretical and

practical usage, perhaps aligned with the Enterprise-view of Project 13 (ICE, 2018). Both encourage a value and outcomes related view of investment appraisal and benefits realisation.

3. The linkage between project-organisation sustainability reporting can be increased by explicitly labelling project level thematics areas by TBL headings. Given that most users do not have recognition of the TBL terms, an overlay of explicit 'signposting' to the TBL could be applied and supported by further L&D.
4. SDGs in both project level and organisational level reports need to be explicitly referenced.
5. Economic TBL-IVC issues at project level need to be explicitly increased, so that TBL parameters are considered holistically across economic, social and environmental related topics. This could include a mechanism to cost social and environmental impact/value so that economics aspects more explicitly drives the TBL sustainability decision-making process.
6. With strengthened requirements for reporting at government and industry levels, the collection of reporting data at project level should be centralised and shared, in order to allow knowledge sharing and increase efforts to improve results.
7. Project level reporting increases the linkage to economic targets to emphasise the overlapping areas of influence across all three TBL. This is of greater significance to the second area, post-project, shown in **Error! Reference source not found.**. By doing this, there will be increased recognition by senior managers of their interconnectivity.

TBLs are currently reported in silos at project level and this loses understanding of potential positive and negative impacts of the investments. For example, increased use of TBL valuation tools, from the start through to project completion, would strengthen investment decisions-making and analysis of lessons learned.

5.2 Test 2 - does Ceequal map to SDGs?

The second test explored whether Ceequal could be mapped to SDG global goals. The outputs from the full matrix mapping tool is shown at Annex A, and the high-level results of this analysis are shown below in **Error! Reference source not found.**. The pie chart indicates a strong focus (50%) on environmental issues, with approximately a half of the questions spread across the economic (19%) and social (34%) TBL related areas.

The bar chart illustrates the relative connectivity (i.e. touch points) across the individual SDGs which is further illustrated in the systems mapping diagram shown below in **Error! Reference source not found.**.

The results of the analysis from Test 2 are as follows: Three of the SDGs (9, 12 and 15) have strong connectivity (where a linear, evidence-based, linkage can be identified that could provide an objective level of 'attribution') to Ceequal; eight of the SDGs (3, 4, 6, 7, 8, 11, 13, 14) have an indirect connection (where a linkage is identified at a 'contribution' level which is without an evidence-base to objectively substantiate the link) and six have low or no connection (1, 2, 5, 10, 16, 17). This provides insight to the prioritisation process at a project design stage as to which SDGs are used to assess SDG impact. There is confidence that a link can be made from project level tactical activities and outputs to the more strategic level

outcomes and impacts of SDGs.

Examples of these three categories are as follows:

- Strong connection identified: Target 6.1 (see **Error! Reference source not found.** for SDG, with 169 targets at https://sustainabledevelopment.un.org/sdgs), *By 2030, 'achieve universal and equitable access to safe and affordable drinking water for all'*, that can be captured by Ceequal under question 3.5.4, which relates to the number of people with access to safely managed drinking water. Attributes could for instance be the increased number of local communities who have access to clean water.
- Indirect connection identified: Target 7.3, '*By 2030, double the global rate of improvement in energy efficiency'*, that linked to Ceequal question 8.4.1-4, 8.5.1-2, but where there is no attribution metrics to justify this linkage.
- No connection identified: Target 8.1, '*Sustain per capita economic growth in accordance with national circumstances and, in particular, at least 7 per cent gross domestic product growth per annum in the least developed countries'*, which is not relevant to project level measurement and no metrics identify contribution to the improvements.

5.3 Limitations of the research

The authors recognise that the analysis can only be considered as early exploratory research without definitive conclusions. However, it is offered as a way of supporting the infrastructure community to design methods to align project delivery better with SDG strategic impacts. The specific limitations of the approach were as follows: the matrix mapping was only completed

by the authors and should be more widely tested to strengthen the findings; and the text analysis technique provides only limited indications. Consequently, these are not conclusive findings because the terminology is nuanced and specific to the contextual purpose of the methodology in relation to its organisational level; and finally; the SDG targets analysed are specifically designed for national level measurement and as such, are not easily cascaded to project or organisational level, thus reducing the strength of linkage between them.

5.4 Contribution of the findings to the field, further research and potential applications

The aforementioned limitations suggest that this exploratory research study has not provided definitive findings. However, it has helped narrow the scope of further research by establishing priorities for the final research design. The research supports an improved understanding of sustainability of civil infrastructure and its relationship with global SDG goals, which will help define how society adapts to future 'grand challenges'. Today, too little is done to link project sustainability to more strategic and transformative global goals. In this context, further research and potential applications include:

- Continue research into improving the understanding of the linkage between project level success, organisational level success and the global SDG goals.
- Develop our understanding further on how to embed SDG impact targets at the design stage of an infrastructure project, thereby providing a more robust investment appraisal at the project design phase. This will help define project success more widely across the 'Triple Bottom Line' (TBL) of economic, social and environmental outcomes as well as associated impact.

- Build an agreed, common, accessible and adaptable database of indicators and a corresponding criteria framework that can be used to select measurements at the project level that are aligned with specific SDG targets and indicators.
- Conduct a case study investigation to build more detailed qualitative and quantitative data, which the findings of the exploratory research can be tested against.

With these further developments, the research will likely provide more meaningful insights into how infrastructure investment can be focused, and lessons learnt that increase impact across SDGs will be applied more effectively. Civil engineering practitioners are encouraged to reflect on the findings from this research and consider how sustainability can be incorporated throughout the project lifecycle – from the design to construction, operation and disposal stages. As described herein, infrastructure investment and the corresponding projects represent a major opportunity for the construction sector to establish sustainable building practices in the industry that reduce environmental impacts and help construction enterprises to remain competitive. Moreover, this research has attempted to tackle the inherent complexity associated with the SDG framework and supporting indicators as well as the challenge of how to measure performance against such goals for infrastructure projects. In this context, the civil engineering community is well placed to contribute to further developments in the field through applying the findings from both theoretical and empirical research to improve the measurement of SDGs and drive sustainability across the sector.

6. Conclusions

This paper summarises research into the existence of a ‘golden thread’ between sustainability

reporting at the tactical delivery-level of projects and the strategic-level outcomes and impacts of the UN's 17 Sustainable Development Goals. The research selected the Ceequal reporting methodology at project level and the GRI methodology at organisational level since both approaches had the best attributes of accessibility, wide usage, currency and credibility. The results from this research study indicate that the golden thread can be evidenced across the TBL themes of economic, social and environmental thematic areas, at both project and organisational levels. It also showed that there is confidence that tactical-level sustainability tools on projects can be widened to include SDG linkages. This has particular value to stakeholders when assessing both the project delivery phase of related TBL success definition, as well as the second phase (i.e. post-project), of the wider project outcomes and SDG impacts. Given the findings from the research the hypothesis of '*The proposed IVC Transformation Model provides a 'Golden Thread' linking sustainability frameworks at project and organisational levels with SDG impacts'* was supported, albeit with the stated limitations and according to the defined spectrum of high-to-low connections across the Ceequal to GRI linkages and the Ceequal to SDG linkages.

The authors offer the findings as exploratory insights. In doing so, they suggest that there is sufficient linkage strength and coherence to embed SDG impact targets at the design stage of an infrastructure project. This provides a more robust investment appraisal at the project initiation, and importantly, defines project success more widely across the 'Triple Bottom Line' (TBL) of economic, social and environmental outcomes and impact. The evidence of the golden thread also offers the opportunity to develop industry-based case studies across large

construction projects in their design phase to develop knowledge in this important area. This will provide increased confidence in the investment decisions, managing short-term economic drivers of business success with mutually supportive alignment of economic and social impact success. The research therefore concludes by proposing the Infrastructure SDG Impact-Value Chain as a basis for testing on 'live' projects. A supporting roadmap should be developed to support this next phase of research that will enable consistent use of the IVC methodology, thereby increasing its value and applicability across the infrastructure sector.

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This paper summarises a research project between the Institution of Civil Engineers, the Nathu Puri Institute for Engineering and Enterprise at London South Bank University and the BRE, to understand alignment opportunities between existing sustainability reporting methods at project-level, and the emergent reporting protocols of the Global Research Initiative at the organisational level in order to identify a 'golden thread' to SDG impact reporting.

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Table 1. IVC Grid illustrating Golden Thread mapping of the TBL with the 5 stages of the IVC

	Input	Activity	Output	Outcome	Impact
Economy	Finance / investment; insurance; risk contingency allocations; WLC analysis; stable government; non-corrupt financial context;	Job creation; income; wages; source, move & assemble materials; build iteratively through defined activities such as early earthworks; local & wider supply chain activity	Project completion to time/cost/scope – bridge, building, road etc.; income; profit; taxes; Net Present Value provides strong RoI against Whole Life Costs;	Economic growth enabled by completed assets as a system; more resilience; wealth creation; ownership; increased future investment and additional job creation	SDGs 8, 9, 10, 12
Social	People; social networks; cultural and technical knowledge; listening & working with stakeholders;	Collaborative innovation; health & wellbeing; stakeholder engagement; skills and learning; working conditions; production activity; user engagement;	Asset's social utility; meeting stakeholders' objectives; individual and group learning and post project knowledge sharing;	Infrastructure enabled change across health, education etc., e.g. reduced mortality; gender equality; social equity; justice;	SDGs 1,2,3,4,5,7,11
Environment	Raw materials; land take; water; light; clean air; energy; planned land use; ecology ecosystem valuation assessment;	GHG emissions; pollution; noise and air quality; works' affects pre and during production e.g. waste management, nitrogen, CO2, acidification levels	Managed effects on completion of asset; replanted trees etc.; improved local area; no net loss on eco system footprint; short term environmental targets met;	Restored/ improved biodiversity and natural balance e.g. increased long-term positive effect on environment through improved sustainability	SDGs 6,13,14,15

Table 2. Comparative definition of CEEQUAL and GRI

Feature	CEEQUAL	GRI Standards
Coverage	• Project level.	• Organisational level.
Sectors	• Infrastructure / built environment across public, private and NGOs.	• All sectors across public, private and NGO.
Accountability	• The project director takes accountability for the report and its management.	• Report usually authorised by the Corporate Board.
Responsibility	• Voluntary.	• Voluntary.
Assessed	• Verification and rating issued.	• Self-assessed, with option of external assurance - although only 31 (1.1%) of the 2,902 reports uploaded to-date in 2018 and analysed on the GRI database, described their external assurance as 'Reasonably High'. No rating given on reports.
Transparency	• Detail kept private but award rating made public unless the client opts out of sharing data.	• Public.
Fairness	• A tightly controlled structure with assessment of evidence provides a balanced rating award.	• The GRI standard is widely used although only a small % use the full report, and very few (31 out of 2,902 in 2018) have a high level of external assurance.
Measurement against TBL	• Implicit (embedded within criteria focused on project team delivery).	• Explicitly structured on the three core areas of: GRI 200 Economic; GRI 300 Environmental; GRI 400 Social.
Link to SDG	• No current linkage.	• No current linkage, although GRI part of UN Global Compact (UN-Business leaders' group for SDGs) to build connections e.g. SDG Compass has a methodology to do so.
Updates	• New version to be launched in June 2019.	• New GRI Standards launched in July 2018.

Table 3. Selected Manuals for analysis: CEEQUAL and GRI

Methodology Manual	Title	Pages	Words
CEEQUAL	CEEQUAL V5.2 Technical Assessment Manual	148	77,698
Global Reporting Initiative	Consolidated Set of GRI Sustainability Reporting Standards 2018	542	152,797

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Table 4. Data Analysis using NVivo: Nodal-Word linkages. Column description: f1 = the average % of the 42 Key Indicator Words usage in the combined documents of CEEQUAL and GRI Standards; f2 = the nodal average %; f3 = the sub-node %; f2.1 and f3.1 are the GRI average % use of each key word within the nodes and sub-nodes; f2.2 and f3.2 are the equivalent for the CEEQUAL document

							GRI				CEEQUAL			
	f1 %	**Primary Node**	**f2 %**	**Sub-Node**	**f3 %**	**Key Indicator Words**	**# of occurrences**	**% for document**	**f2.1 %**	**f3.1 %**	**# of occurrences**	**% for document**	**f2.2 %**	**f3.2 %**
Impact-Value Framework	**0.3**	**Impact-Value Chain (IVC Concept 1)**	0.14	Ends' Impact-Value Chain	0.18	Value	100	0.01	0.20	0.27	96	0.2	0.16	0.24
						Impacts	976	0.97			267	0.55		
						Benefits	86	0.09			75	0.15		
						Outcomes	11	0.01			30	0.06		
				Ways & Means' Impact-Value Chain	0.1	Outputs	10	0.01		0.13	16	0.03		0.07
						Activities	361	0.36			79	0.16		
						Inputs	31	0.03			13	0.03		
		Impact-Value TBL / SDG (IVC Concept 4)	0.37	TBL	0.53	Economic	633	0.63	0.43	0.58	159	0.33	0.31	0.48
						Environmental	546	0.54			395	0.8		
						Social	578	0.57			147	0.31		
				Sustainable Development	0.21	SDG	0	0		0.28	0	0		0.15
						Sustainability	557	0.56			140	0.29		
		Impact-Value Structures (IVC	0.37	Hierarchy	0.7	Project	81	0.08	0.22	0.14	1186	2.44	0.52	1.26
						Organisation	204	0.2			37	0.07		
				Employment	0.17	Employment	408	0.4		0.31	13	0.03		0.04

		Concept 2)				Safety	331	0.21			25	0.05		
				Stakeholders	0.24	Client	0	0		0.22	289	0.38		0.26
						Supplier-contractor	443	0.44			101	0.2		
						Stakeholders	279	0.28			32	0.07		
						Communities	160	0.16			183	0.38		
		Impact-Value Reporting Thematics (IVC Concept 3)	0.20	Thematic Topics	0.23	Water	580	0.58	0.21	0.24	236	0.49	0.20	0.22
						Energy	189	0.19			131	0.27		
						Health	390	0.39			34	0.07		
						Transport	55	0.05			121	0.25		
						ICT	0	0			0	0		
				Footprint	0.18	Emissions	393	0.29		0.18	60	0.12		0.18
						Effluent/discharge/waste	219	0.23			209	0.43		
						carbon	13	0.01			72	0.15		
						GHG	187	0.19			12	0.02		
		Impact-Value Management process (IVC Concept 5)	0.53	Capture of responses and data	0.52	Disclosure	1786	1.78	0.23	0.45	0	0	0.83	0.60
						evidence	0	0			638	1.31		
						methodology / process	114	0.11			137	0.28		
						Assessment	267	0.27			607	1.25		
						achievement	66	0.07			82	0.17		
				Quanitfying relative success	0.53	score	0	0		0.01	808	1.66		1.06
						verifiers	0	0			60	0.12		
						monitoring	15	0.01			120	0.25		
						award	9	0.01			46	0.09		
		Sector /	0.29	Commercial	0.17	legal	125	0.15	0.12	0.22	72	0.15	0.47	0.13

		Commercial				contract	284	0.28			56	0.1		
				Sector	0.41	Construction / Infrastructure	27	0.03		0.02	678	1.39		0.81
						Engineering	0	0			112	0.23		

Table 5. Key data results from the NVivo text analysis (See Annex for full data)

Nodes	CEEQUAL	GRI
Impact Value Chain (Concept 1)	• CEEQUAL uses 'impact' but at a level of half the frequency of GRI. It tended to use 'value' and 'benefits' more, perhaps as compensation. • Both rarely used 'outcomes' that suggests the Theory of Change and global programme management terms are not well known or widely used.	• The GRI had the strongest alignment to Theory of Change terminology, especially 'Impacts' (0.97%) – i.e. almost 1 in every 100 words. • GRI rarely uses 'value' or 'outcomes', both at less than 0.001%. (**R1**)
TBL (IVC Concept 4)	• CEEQUAL had fewer references to 'economic' factors (0.33% vs. 0.63%) but has implicit economic criteria embedded in the efficiency of the management processes that address the sustainability questions. Both CEEQUAL and GRI had no reference to 'SDG' (0%). (**R2, R3**)	• GRI had stronger reference to the two of the core areas of TBL ('Econ', 0.63%; 'social', 0.57%). • GRI had stronger reference to 'sustainability' (0.56%)
Structures (IVC Concept 2)	• CEEQUAL has an explicit focus on the 'project' level (2.5%) but an equal focus on stakeholder engagement. It has greater focus on 'communities' (x2) and a main focus on the client – in effect, CEEQUAL is about the value chain working better. • The high use of 'communities' could have been aligned with 'social' in the TBL/Concept 4 – they are synonymous.	• GRI has an explicit focus on the 'organisational' level and a greater focus on 'safety' (x4 of CEEQUAL, which recognises there are other tools covering safety at project level) and 'employment' (x10).
Reporting (IVC Concept 3)	• Both levels give equal priority to thematic reporting across 'water/energy' etc. • Neither capture 'digital/ICT' impacts because as shown in **Error! Reference source not found.**, ICT is only relevant in the outcomes post-project.	• Both have equal focus on footprint areas ('GHG', 'emissions', 'discharge' at 0.18%). • 'Carbon' is rarely used by both.
Management processes – e.g. this relates to the process of	• CEEQUAL has a significantly greater interest in 'score', 'verify', 'monitor', 'award', 'assessment'. This indicates the strong focus on verifiable evidence.	• Both have a similar level of emphasis on the capture of 'response' data. GRI uses the term 'disclosure' as primary term. The reports are

CEEQUAL and not what is being assessed	In effect, this gives it teeth, albeit, in a low reputational risk way – data remains confidential. • Also, 'achievement' sits across a number of nodes because it also aligns with 'outputs and outcomes' of the IVC in the first node. The focus of CEEQUAL assessment is split between internal governance and external verification.	loaded onto the GRI website, but the strength of reporting varies significantly, which is not easily identified on the website. • Whereas, for CEEQUAL, the assessment is about encouraging verification so that they are having the right discussions on the right issues, early enough to impact sustainability. Thus, CEEQUAL is proactive, GRI is more reflective in approach. (**R4**)
Sector specific / commercial	• The focus on 'infrastructure' and 'construction' was reflected in the key word usage (1.4 in every 100 used).	• Very low reference to specific sectors since GRI is for all sectors. • Similar use of 'legal' but more use of 'contract'. (**R5**)

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Figure 1. The Global Goals. The UN 17 Sustainable Development Goals (*graphic usage confirmed at* https://www.un.org/sustainabledevelopment/news/communications-material/*)*

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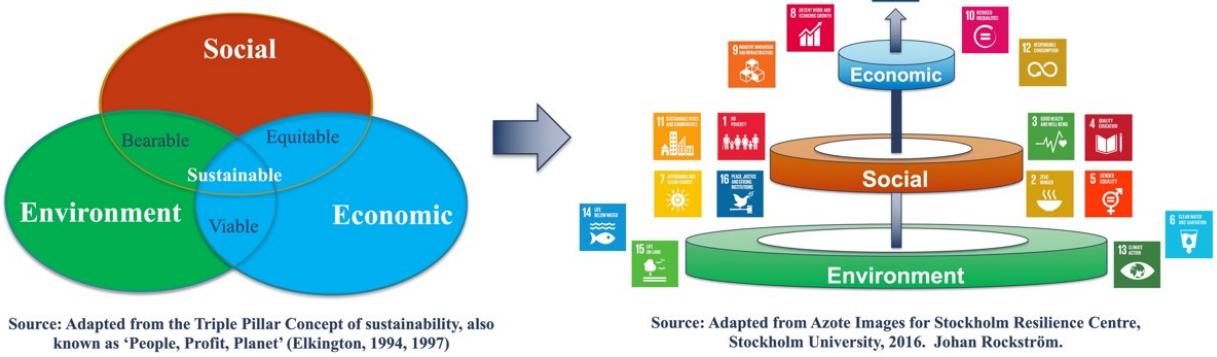
Figure 2. The Triple Bottom Line (TBL) view of Economy, Environment and Social translated into the donut view (aka 'wedding cake') of SDG alignment by Johan Rockström (2016)



Source: Adapted from the Triple Pillar Concept of sustainability, also known as 'People, Profit, Planet' (Elkington, 1994, 1997)

Source: Adapted from Azote Images for Stockholm Resilience Centre, Stockholm University, 2016. Johan Rockström.

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Figure 3. Framework for sustainability and project success reporting depicting the two core sustainable development questions at project level

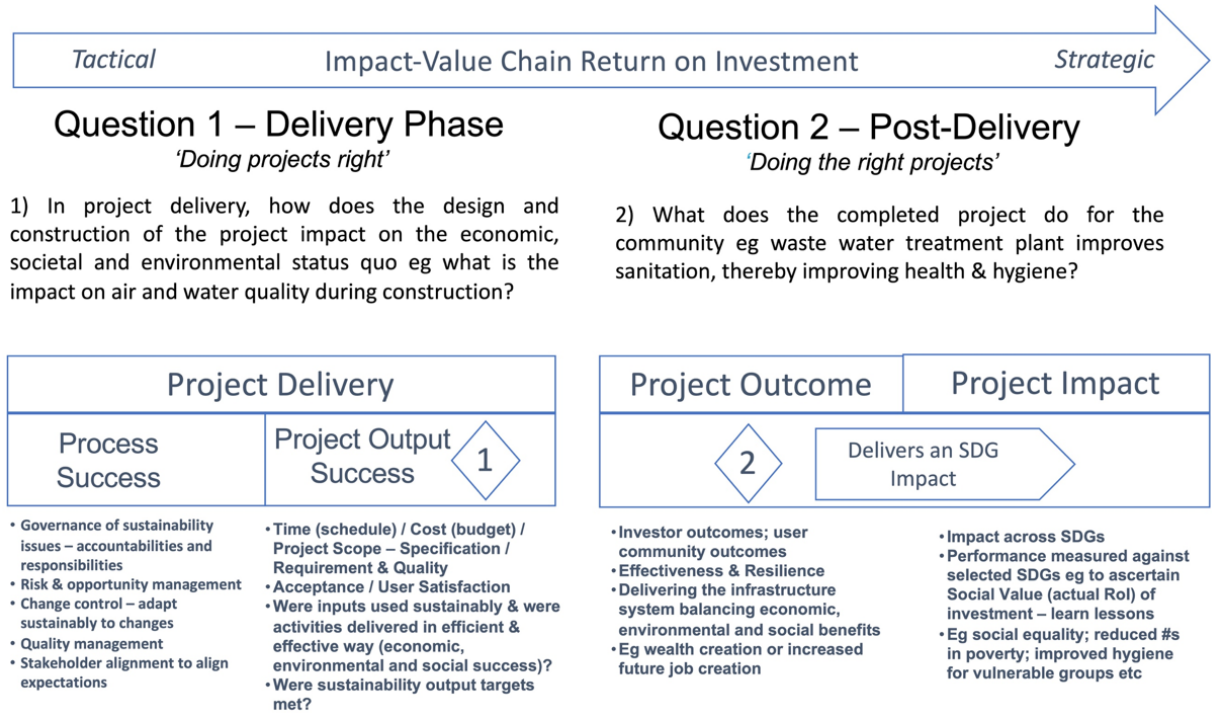

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Figure 4. SDG Hierarchy of SDG target reporting using Impact value Chain (IVC) outcomes and impact causal chain

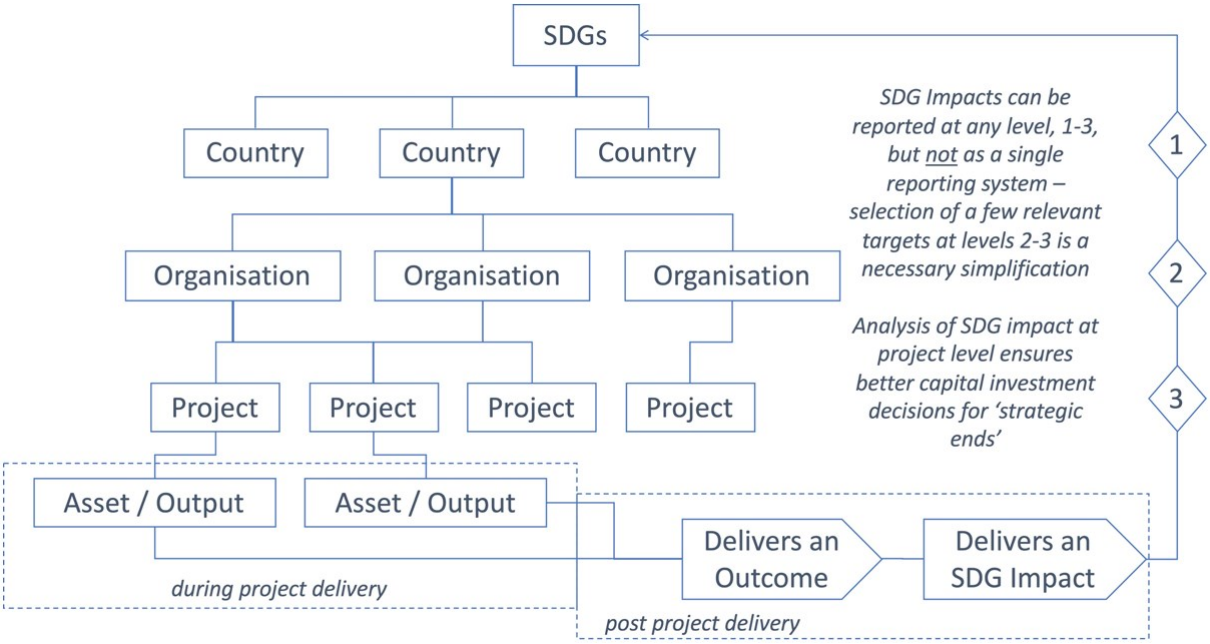

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Figure 5. The Infrastructure SDG Transformation Process Model – The Impact-Value Chain (IVC). Adapted from ICAS/IIRC's 'The Sustainable Development Goals, integrated thinking and the integrated report' (Adams, 2017)

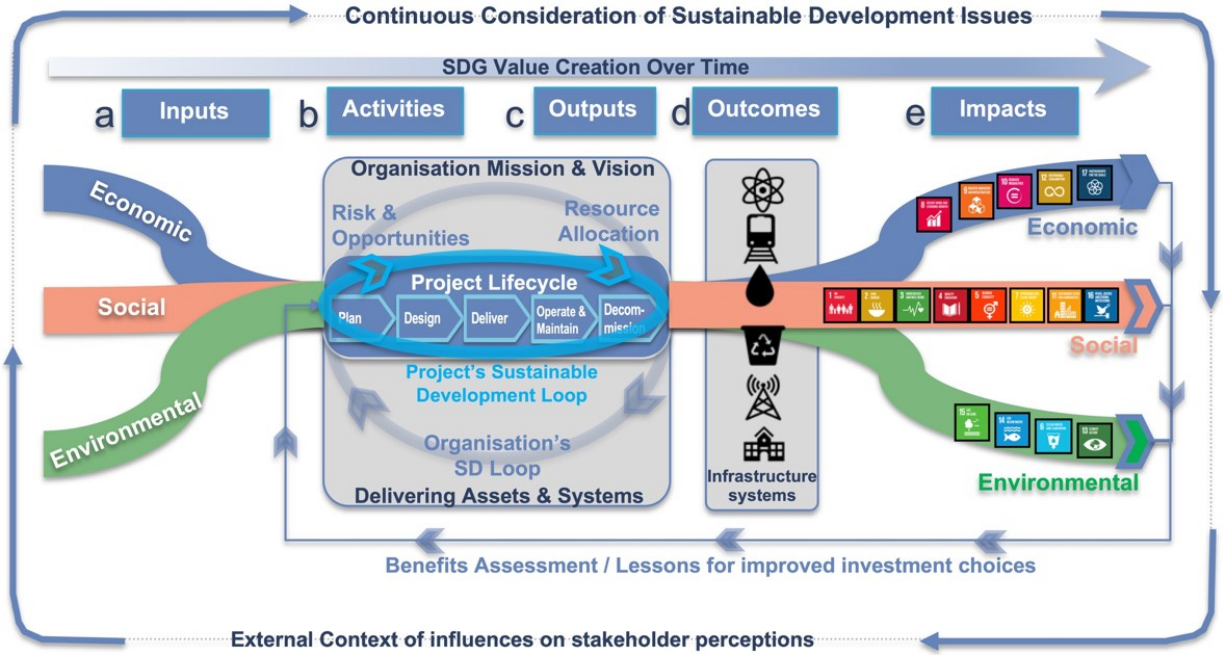

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Figure 6. Analysis methodology framework

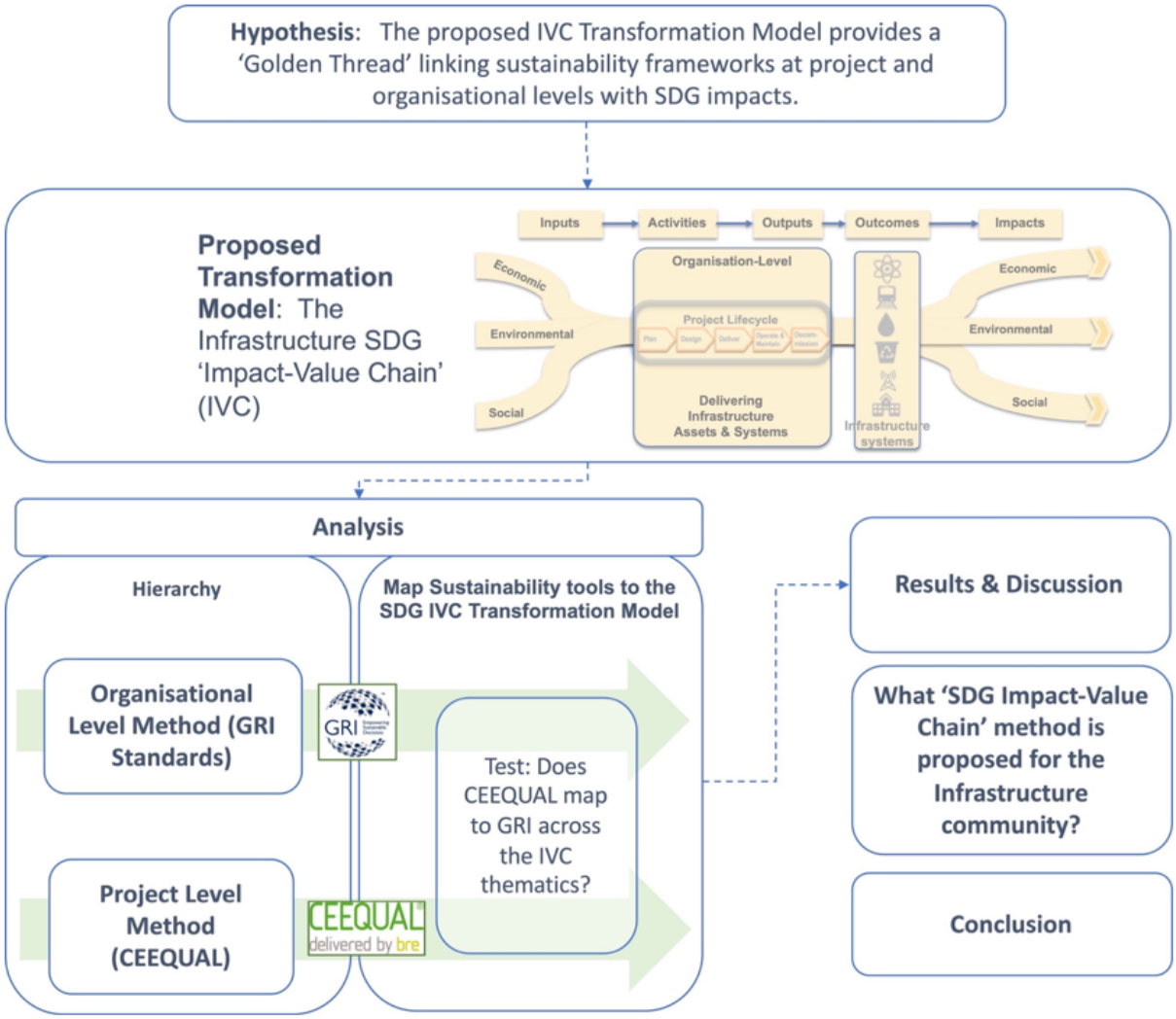

Figure 7. Tree map linking IVC four concepts to the Key Indicator Words via nodes and sub-nodes

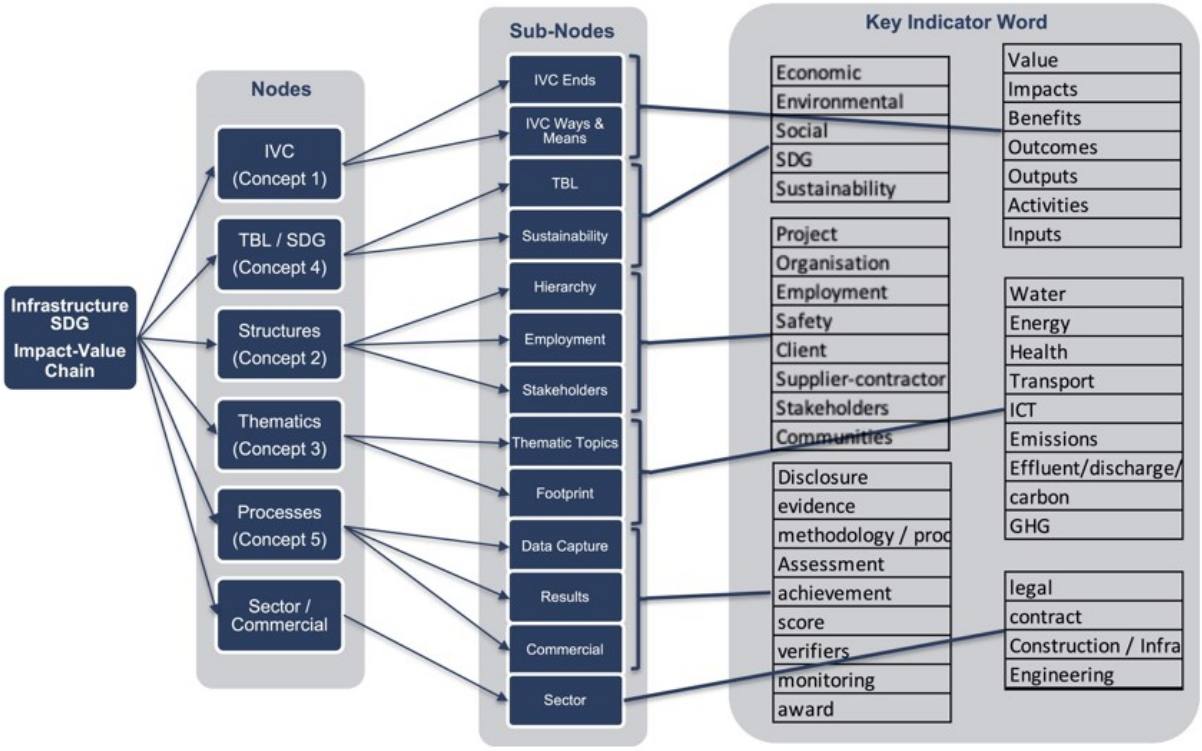

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Figure 8. High-level Analytical Matrix Mapping showing linkages between Ceequal Categories (y-axis) with GRI Materiality Topics (x-axis)

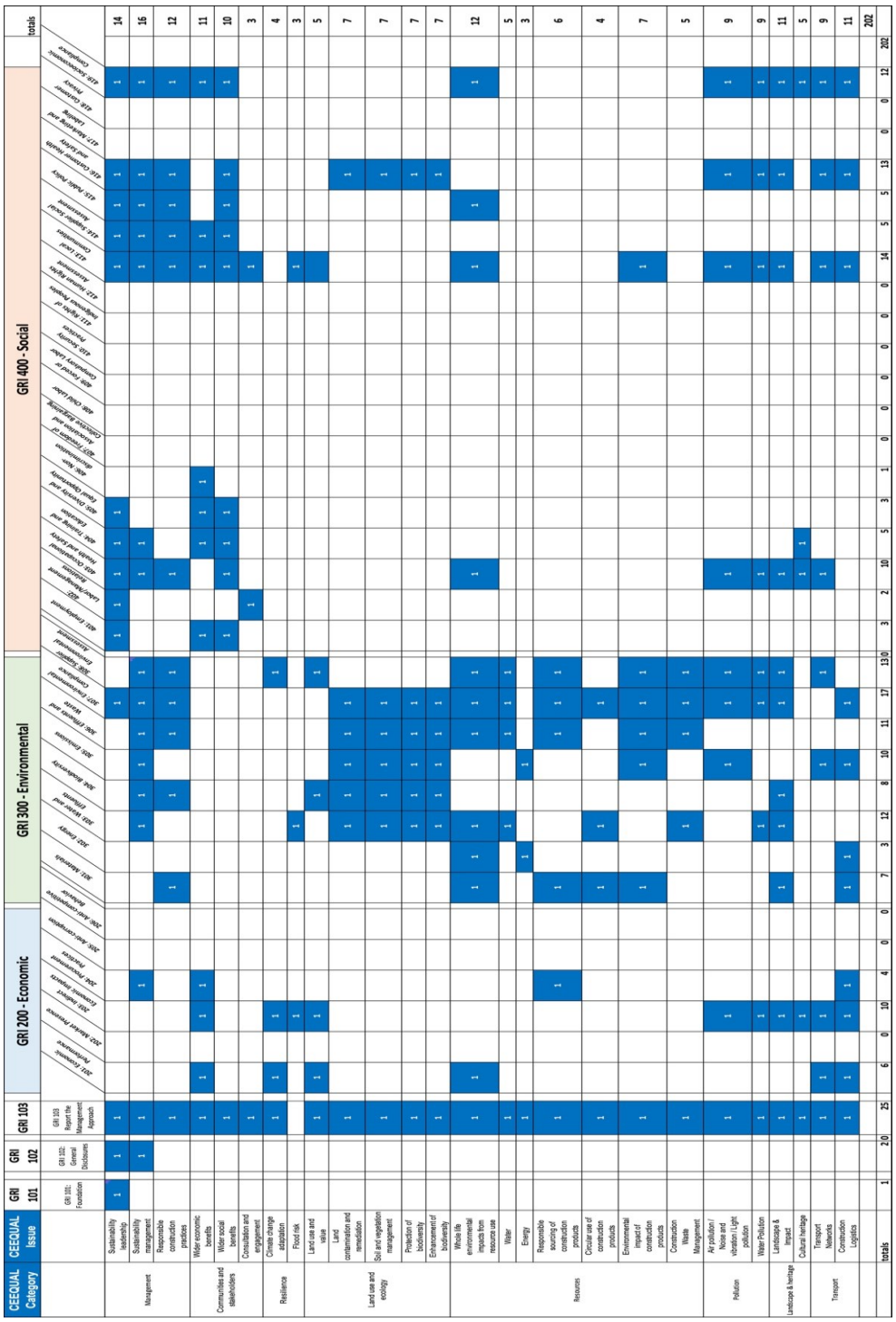

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Figure 9. Bar Chart showing the instances of 'hot spots' where alignment is identified. Y-axis shows the number of occurrences in Ceequal's 246 questions; Back= GRI 200 Economic Material Topic, Grey = GRI 300 Environmental, Light Grey = GRI 400 Social

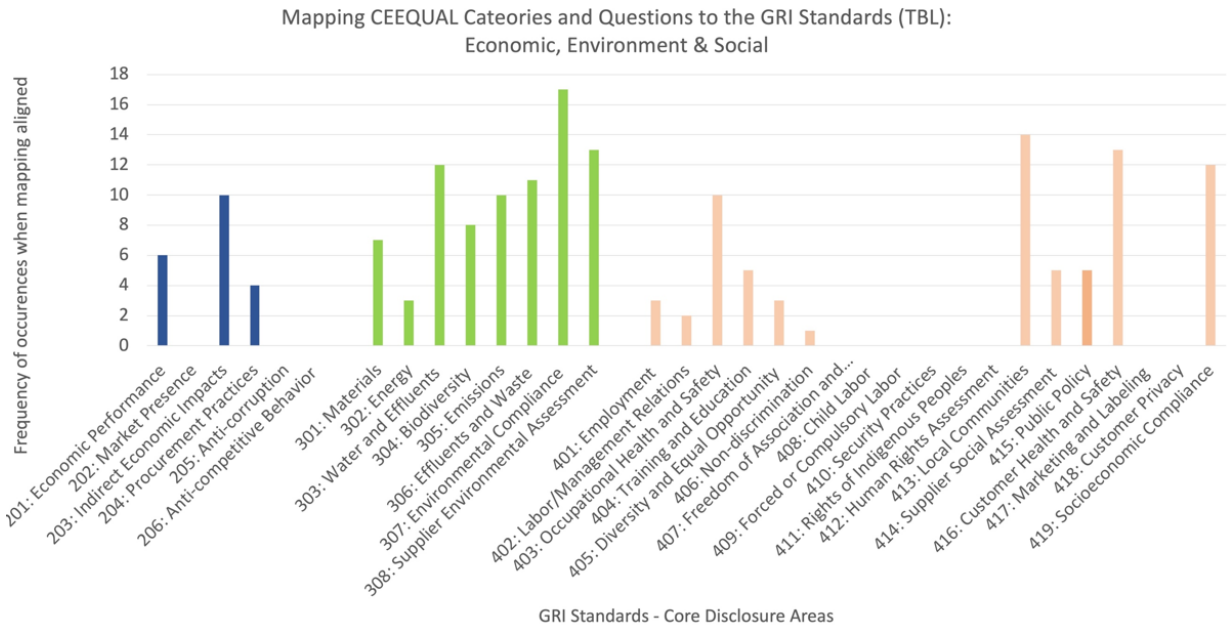

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Figure 10. Data captured from NVivo analytical tool showing strength of connections across the 4 concepts in IVC from project level to organisational level (full data in Annex). For description of the columns, see Table 4 title

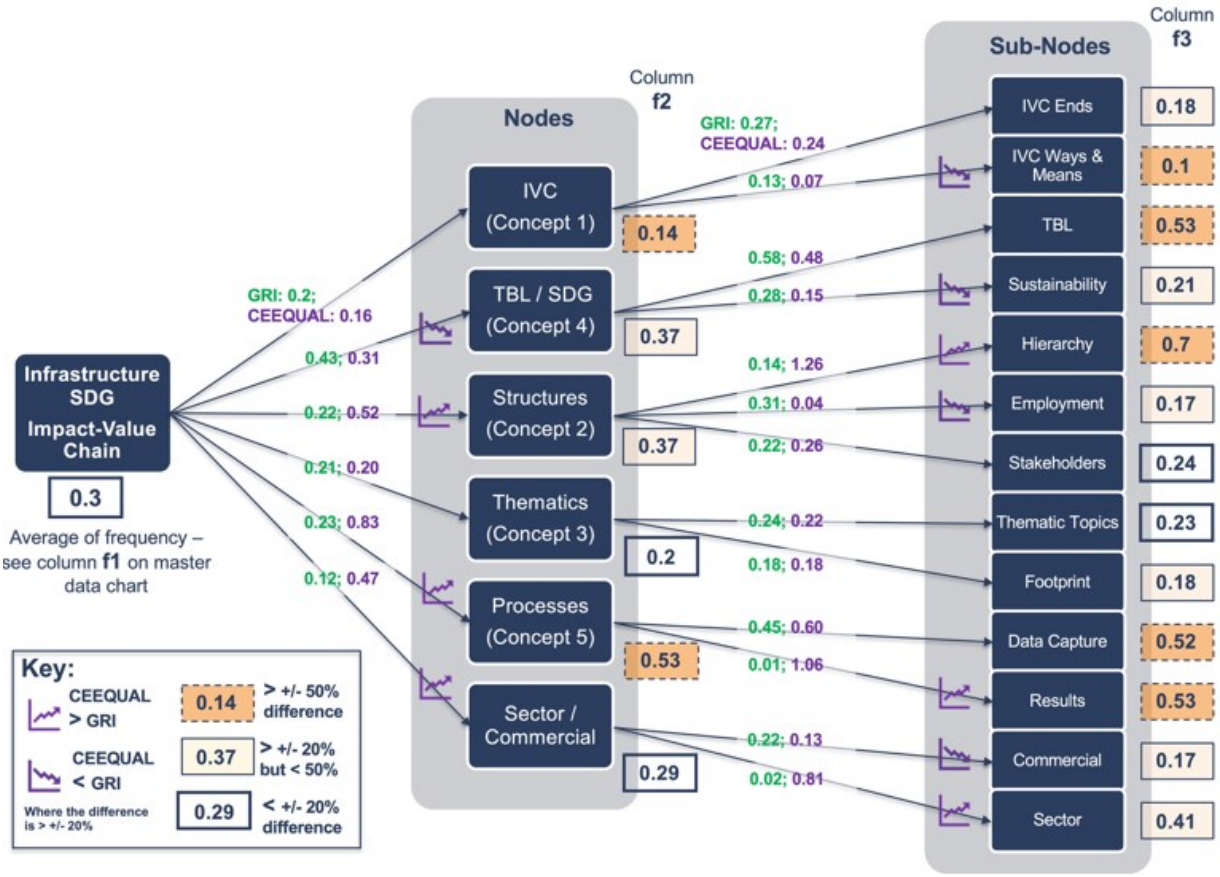

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Figure 11. Ceequal's relative focus on TBL and across SDGs (full matrix analysis shown in Figure 13)

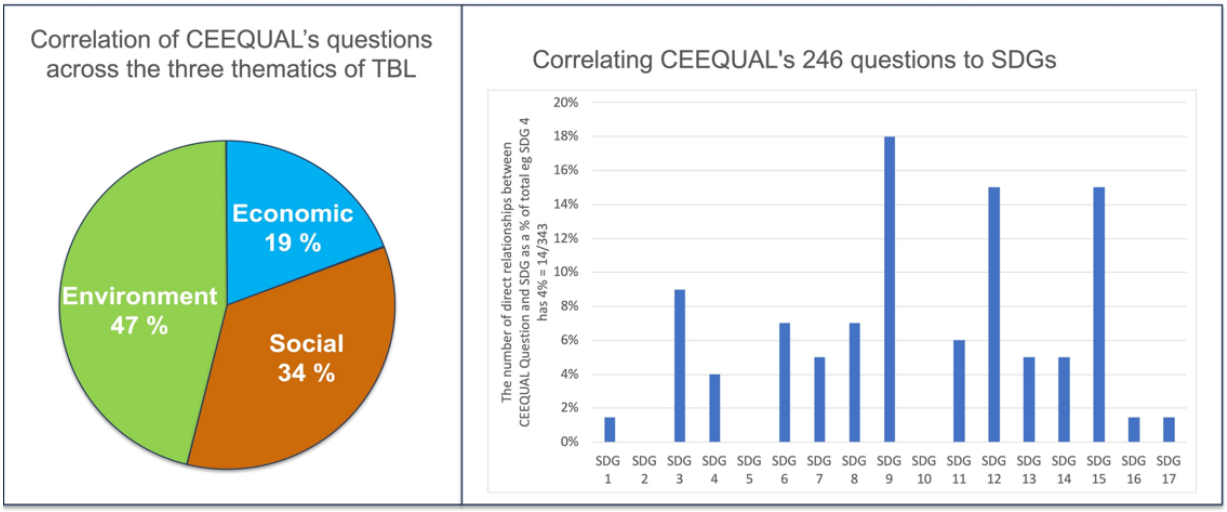

Figure 12. Systems mapping of connections between Ceequal and SDGs