MEASURING INFRASTRUCTURE PROJECTS SUSTAINABLE DEVELOPMENT GOALS IMPACT (MISI)

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A thesis submitted in partial fulfilment of the requirements of London South Bank University for the degree of Doctor of Philosophy

This research was carried out in collaboration with a number of partners including the Institution of Civil Engineers, University College London, the Buildings Research Establishment, the Cabinet Office's Infrastructure and Projects Authority, the Environment Agency, Thames Tideway Tunnel Ltd and the UN Global Compact.

May 2021

Acknowledgements

There are so many people who deserve my thanks without whom this thesis would not have been written. I have no doubt that the moment I submit I will realise I have missed so many of you from this list.

First of all, I must acknowledge my constantly supportive wife, Jo Mansell. I could not have done this without you. I would not have even thought this possible without you. You are my rock.

I owe a huge amount to my supervisors, especially my First Supervisor, Professor Simon Philbin (Director, Nathu Puri Institute for Engineering and Enterprise, London South Bank University), who provided the excellence of doctoral support that the study into PhD Supervision by Lee (2008) characterised as the 'right blend of functional, enculturation, critical thinking, emancipation, and the development of a quality relationship' where supervisors use emotional intelligence to enthuse and care for their students. He could not have performed these support roles more effectively and I doubt I would have completed the research without his level-headed and pragmatic approach to the balance of studies and ongoing government support as well as my teaching commitments at UCL. I especially welcomed the freedom to develop my own design for the MISI research project, harnessing my existing relationships across government and industry. I was also fortunate to have excellent support from my Second Supervisor, Professor Rao Bhamidimarri (President, Institute of Advanced Research, Gujarat, India), who was the reason why I joined the NPI team; and, my Third Supervisor, Dr Efrosyni Konstantinou (Associate Professor, Bartlett School of Construction and Project Management, University College London). You have each looked out for me in different ways and I have benefited from you as a team. I am particularly indebted to Ralf Müller, Professor of Project Management at BI Norwegian Business School, who provided a number of support interventions, including an academic writing course, pro bono.

I am also indebted to the research partners listed on the front page of this document, with special thanks to Professor Tim Broyd (UCL, ICE and BRE), Ian Nicholson (BRE), Deney Van Rooyen (Cape Town University) and Dr Luca Sabini (Hertfordshire University), Nick Baveystock (Director General Institution of Civil

Engineers); Nathan Baker (Director Knowledge, formerly ICE); Elodie Huiban (Knowledge Strategy Manager, formerly of ICE); David Hancock and Alison Baptiste (Directors, Infrastructure and Projects Authority, UK Cabinet Office and HM Treasury); Fergus Harradence (Deputy Director, UK Department of Business Enterprise, Innovation and Skills); John Russon and Kat Ibbotson from the Environment Agency; Steve Kenzie (CEO, UN Global Compact UK); Ines Faden (Group Treasurer, Thames Tideway Tunnel); without whom this research would not have been possible. To the many company leaders and engineers who took time to complete surveys and participate in interviews and workshops – thank you for your patience and support.

I would also like to thank: Professor Andrew Davies as my Viva external examiner who, as a global leader in the field of systems integration and complex project management delivery, provided challenging and insightful commentary at my Viva with Dr Sara Hasani Darabadi as the internal examiner; Dr Juliano Denicol, Associate Professor UCL and Dr Christine Unterhitzenberger, Associate Professor in Project Management at University of Leeds, who acted as the examiners for the mock Viva, that greatly contributed to the success of the Viva; Professor Phillip Burrell and Dr Deborah Andrews for their commitment to my development demonstrated in RES panels; fellow Nathu Puri team members, including Sunita Selvarajan, Thomas Empson and Pavan Kumar Sala; Dr James Smith-Spark who supported my SPSS queries; and finally, fellow co-authors who supported the formal publication of 7 papers in academic journals and 5 conference papers. On all these 12 papers, I can confirm that 95% of the design and analysis was my work alone – a full list of them is at Appendix 24.

Abstract

The research captured in this thesis has led to the development of a range of models, tools and processes for government and industry that provide a forward-looking approach to the measurement of impact on infrastructure projects. This approach enables measurement of United Nations' Sustainable Development Goals (UN SDG) at the project level to ensure investments are made equitably across economic, environment and social objectives. Application of the results from this research are already being actively used by the Environment Agency to manage impact assessment across its £5.2Bn portfolio of projects and by the Thames Tideway Project (£4.9Bn).

Background. Achievement of the United Nations' Sustainable Development Goals (SDGs) by the year 2030 is of paramount importance and the construction industry has a major role in achieving a measurable impact against the SDG targets. However, linking of 'local' infrastructure project success to 'global' SDG targets is problematic because the targets were designed at the national level and not at the project or programme level (Mansell, et al., 2020a). Furthermore, while the so called 'triple bottom line' (i.e. economy, environment and society) approach to understanding sustainability remains important, there is a need to understand how this can be related to the full project lifecycle as well as a need for improved project governance. This is consistent with the findings of a key UN investigation's Fourth Report (Global Task Force, 2020) which calls for localization of SDGs as well as the need for cooperative governance to establish shared priorities.

Research description. The research was based on two main stages. The first stage, informed by a systematic literature review, comprised a mixed method that involved a survey of 325 engineers to derive quantitative data (Mansell et al., 2020b) along with interviews with 40 CEOs and corporate Heads of Sustainability to capture qualitative data (Mansell et al., 2020c). The second stage involved the development of a prototype that was tested through two further exploratory investigations at two levels: (1) Test 1: is there a Golden Thread from global SDGs, through the organisational level, down to project level SDG impact measurement?; (2) Test 2: does the prototype model, the *Impact Value Chain*, have practical coherence when

assessed in a brief case study of a Water Utility Company (Anglian Water) (Mansell et al., 2020d). Subsequently, and not part of this thesis, the research led to a collaborative partnership to test the prototype model and its approach across the Environment Agency's full portfolio of projects and also, the megaproject of the Thames Tideway Tunnel.

Findings. The survey of 325 engineers (Mansell et al., 2020b) indicated four primary shortfalls for measuring SDGs on infrastructure projects, namely leadership, tools and methods, engineers' business skills in measuring SDG impact, and how project success is too narrowly defined as outputs (such as time, cost and scope) and not outcomes (longer-term local impacts and stakeholder value). Moreover, the interviews with 40 senior executives (Mansell et al., 2020c) from the UK identified that SDG measurement practices are currently 'more talk less walk' and indicated a number of contextual and mechanistic opportunities to increase the outcome success.

Therefore, using empirical evidence the researcher identified a 'golden thread' between best practice sustainability-reporting frameworks at the 'local' project level and those at the organisational and supra-national-levels (Mansell et al., 2020a). In doing so, the research identified that there is sufficient linkage to embed SDG impact targets into the design stage of an infrastructure project. Furthermore, the innovative process model, called the 'Infrastructure SDG Impact-Value Chain' (IVC) to link project delivery with strategic SDG impacts, builds on the concept of creating shared value and creates a practical mechanism to turn theory into meaningful impact in project selection and delivery. The utility of the IVC process model was initially investigated as part of the case study investigation of Anglian Water (Mansell et al., 2020d) and its application has been further demonstrated in the MISI Project (not included in this thesis).

Research Impact. The research produced twelve peer-reviewed papers including being published in seven internationally recognised academic journals, such as: *Sustainability* (2 articles), *Administrative Sciences*, and the *Proceedings of the Institution of Civil Engineers–Engineering Sustainability*. The MISI research outputs have been taken forward by the government and industry partners, specifically the Environment Agency and Thames Tideway Project, working together to establish this new approach for measuring sustainability on infrastructure projects.

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List of Abbreviations

BRE = Buildings Research Establishment
CR = Critical Realism
CSV = Creating Shared Value
ICE = Institution of Civil Engineers
IP = Infrastructure Projects
IPA = Infrastructure and Projects Authority (Cabinet Office and HM Treasury)
IPCC = Intergovernmental Panel on Climate Change
IVC = Impact Value Chain (MISI model designed as part of this research study)
OPM = Organisational Project Management
RE = Realist Evaluation
SDG = Sustainable Development Goals
SDGiPro = SDG Impact on Projects – a process model for prioritising SDG goals and targets (developed by the research scholar)
TBL = Triple Bottom Line (Economic, Environmental, Society)
ToC = Theory of Change
UN = United Nations
UNOPS = UN Office for Public Services

Key Definitions

(grouped in order of thematics)

Sustainability and the Project Environment

Sustainable Development Goals. '*The Sustainable Development Goals (SDGs), also known as the Global Goals, were adopted by all United Nations Member States in 2015 as a universal call to action to end poverty, protect the planet and ensure that all people enjoy peace and prosperity by 2030*' (UNDP, 2019).

Sustainable Development. Unlike the myriad of definitions for sustainability, the definition of sustainable development is generally agreed from the Brundtland Commission: '*development that meets the needs of the present without compromising the ability of future generations to meet their own needs*' (Brundtland, 1987).

Project. '*A project is a temporary endeavour undertaken to create a unique product, service or result. The temporary nature of projects indicates a definite beginning and end. The end is reached when the project's objectives have been achieved or when the project is terminated because its objectives will not or cannot be met, or when the need for the project no longer exists*' (PMI 2008, p.5). Thus it could be adapted to suggest that '*projects are temporary organisations to deliver clearly identifiable outcomes within the limits of time and cost budgets*' (Davies, 2017; Atkinson, 1999; Lundin and Soderholm, 1995). Uncertainty is an inherent part of a project, '*When projects are complex, unpredictable, and changing, their plans have to be flexible and able to adjust to situations that cannot foreseen at the outset*' (Davies, 2017). '*Within* *a project-based organisation, the project is a business mechanism for coordinating and integrating the business function of the firm*' (Davies and Hobday, 2005).

Programme. 'A *group of related projects managed in a coordinating way to obtain benefits and control not available from managing them individually*' (PMI, 2008).

Megaproject. '*Large scale, complex investments that typically cost a billion dollars and up, take many years to develop and build, involve multiple public and private stakeholders, are transformational, and impact millions of people*' (Flyvbjerg, 2014; Denicol, Davies & Krystallis, 2020).

<u>**Sustainable Infrastructure Systems**</u>

Infrastructure. The Global Commission on the Economy and Climate defined Infrastructure as: 'S*tructures and facilities that underpin power and other energy systems (including upstream infrastructure, such as the fuel production sector), transport, telecommunications, water, and waste management. It includes investments in systems that improve resource efficiency and demand-side management, such as energy and water efficiency measures. Infrastructure includes both traditional types of infrastructure (including energy to public transport, buildings, water supply and sanitation) and, critically, also natural infrastructure (such as forest landscapes, wetlands and watershed protection*)' (Bhattacharya, Oppenheim, and Stern, 2015; The New Climate Economy, 2014)

Sustainable Infrastructure. The definition by Ainger and Fenner (2014) was recently developed further by the Inter-American Development Bank (IDB) Group as: '*infrastructure projects that are planned, designed, constructed, operated, and decommissioned in a manner to ensure economic and financial, social, environmental (including climate resilience), and institutional sustainability over the entire life cycle of the project*' (IDB, 2018).

Systems Thinking. '*An approach that focuses on the identification of interrelationships between components (i.e. sub-systems) of a system'* (Davies, 2004).
Infrastructure System. '*A system comprised of assets, institutions and knowledge that provides a society its services. Examples of National Economic Infrastructure systems are: Water, Energy, Transport, Waste, and Telecommunications*' (UNOPS, 2017; ITRC's Hall et al, 2016).
Assets. Adapted to: '*The physical components of the system. This also extends to the links that exist between the assets in the system. Note that there are man-made assets but also 'Natural Assets', which provide a service*' (UNOPS, 2017; ITRC's Hall et al, 2016). Examples of man-made assets include roads, bridges, power lines, and pipes. Example of natural assets include wetland systems, and mangrove forests.
Services. '*The functions which the infrastructure system enables. Examples include healthcare services, transport services, and education services*' (UNOPS, 2017; ITRC's Hall et al, 2016).

<u>**Logframe**</u>
Theory of Change. '*A basis for planning intervention in a given policy or project arena that helps to identify processes and preconditions whereby actions can best attain their intended consequences*' (Weiss, 1995).

Value. '*The worth of a good or service as determined by the customer's preferences and the trade-offs they choose to make given their scarce resources, or the value the* *marketplaces on an item'* (Porter, 1985). (Note: these are economic-led priorities. Wider societal and environmental considerations are covered in Triple Bottom Line)

Value chain. '*The full range of processes and activities that characterize the lifecycle of a product from production, to manufacturing and processing, to distribution, marketing and retail, and finally to consumption (including waste and disposal across all stages)*' (Porter, 1985; Bloom and Hinrichs, 2011).

Project Logframe. '*A project document normally contains a framework with a list of objectives, activities and monitoring indicators, typically called a "logframe" or "results framework". This framework serves as a basis of implementation, monitoring and evaluation*' OECD (2019).

Impact. Adapted to: '*A positive or negative contribution to one or more SDG targets across the TBL of environmental, economic, or social thematic areas*' (World Bank, 2004). Also, '*What difference does the intervention make? The extent to which the intervention has generated or is expected to generate significant positive or negative, intended or unintended, higher-level effects. Note: Impact addresses the ultimate significance and potentially transformative effects of the intervention*' (World Bank, 2004). Also, '*The effects, both positive and negative, which the project is expected to produce upon environment, organization, community, people, etc.*' (PMI, 2017) '*Positive and negative, primary and secondary long-term effects produced by a development intervention, directly or indirectly, intended or unintended.*' (OECD, 2010)

Project Outcomes. *Adapted to: 'A change in the extent or condition of the stocks of capital (natural, produced, social and human) from the use of an output, due to value-chain activities that deliver SDG impacts'* (APM, 2012). Also, '*The likely or achieved short-term and medium-term effects of an intervention's outputs.*' (OECD, 2010)

Outputs. '*The tangible or intangible product typically delivered by a project*' (APM, 2012). Also, '*The products, capital goods and services which result from a development intervention; may also include changes resulting from the intervention which are relevant to the achievement of outcomes.*' (OECD, 2010)

Activities. '*A task, job, operation or process consuming time and other resources in a project to produce specific outputs*' (APM, 2012). Also, '*Actions taken or work performed through which inputs, such as funds, technical assistance and other types of resources are mobilised to produce specific outputs.*' (OECD, 2010)

Inputs. Adapted to: '*All those items required to undertake work utilising the stocks of capital including financial, natural, produced, social and human resources'* (APM, 2012). Also, '*The financial, human, and material resources used for the development intervention.*' (OECD, 2010)

<u>The CMO Framework</u>

Context (in C-M-O framework). The conditions in a context of action encompass '*material resources and social structures, including the conventions, rules and systems of meaning in terms of which reasons are formulated*' (Sayer 1992, p. 112; in Easton, 2010).

Mechanism (in C-M-O framework). '*The underlying entities, processes, or structures which operate in particular contexts to generate outcomes of interest*' (Astbury and Leeuw, 2010, p. 386).

Outcome (in C-M-O framework). '*The practical effects produced by causal mechanisms being triggered in a given context*' (Tilley 2016, p. 145).

Statement of Original Authorship

The work contained in this thesis has not been previously submitted to meet requirements for an award at this or any other higher education institution. To the best of my knowledge and belief, the thesis contains no material previously published or written by another person except where due reference is made.

(The thesis has 80,002 total words, with additional 16,369 words of References & Appendices)

Signature: 

Date: 14 April 2021

Chapter 1: Introduction

A burning platform for change

Covid-19 has resulted in a 'new norm' (Economist, 2020). The pandemic global health crisis has significantly disrupted the global economy and societies (Economist, 2020). As a result, we are experiencing a transformation in the way society, government and businesses operate. The ways we work, socialize, produce and consume have changed (Economist, 2020). The current situation also highlights the need to ensure the vulnerable are protected and no-one is left behind – in line with the principles of the Sustainable Development Goals (SDGs) (UN, 2015). The SDGs remind us that, despite the urgency of managing the pandemic, the world needs to keep in mind the long-term nature of the circular economy transition and global sustainability objectives including the global climate targets and meeting the needs of future generations (Sachs et al., 2020):

"*The SDGs are needed more than ever. Their bedrock principles of social inclusion, universal access to public services, and global cooperation are the guideposts for fighting Covid-19 as well as for the investment-led recovery the world should adopt to overcome the economic crisis caused by the pandemic*".

However, the latest OECD (2019) and UN (Sachs, et al., 2020) SDG dashboards indicate that the world is falling behind on all SDGs, but especially in the race to avert the climate crisis, which is one of the seventeen SDGs. This acts as a warning beacon for the other SDGs, because as Sachs' notes, the SDGs are interconnected and underperformance on one is likely to have negative impacts on others. For example, 2019 was the hottest year on record, concluding the hottest decade on record (UN Global Compact, 2020), with resulting significant impacts on agriculture (IPCC, 2019) and this impacts the health and wealth of societies. The trend is set to continue. In November 2019, 11,000 climate scientists sounded the alarm, saying the Earth is "clearly and unequivocally" facing a climate emergency and warning that we are running out of time to reverse the trend (IPCC, 2019). We are all impacted by climate change that threatens the livelihoods and safety of billions of people. There is some positive news, such as the announcement at the UN General Assembly in September by Chinese President, Xi Jinping, that China aimed to go carbon neutral by 2060. However, as Antonio Guterres, the UN Secretary General, says, our immediate and concerted global efforts in 2021, and specifically at the UK-hosted COP26*, "is a make or break moment for the issue*" (BBC, 2021).

1.1 OVERVIEW OF INTRODUCTION CHAPTER

This introduction chapter states the objectives of this programme of research into the Measurement of Infrastructure projects' SDG Impact (MISI) and includes definitions of the key concepts and variables, as well as providing a brief outline of the background and research approach.

This chapter outlines: the background (section 1.2); the context (section 1.3) of the research; my Personal perspective – Adopting the Kolb Learning Cycle (section 1.4); the purpose of the research, including the what, why, how, when (section 1.5); the significance, scope and definitions (section 1.6); the thesis outline (section 1.7); and as with all chapters, it will conclude with a summary (section 1.8) and a link to the next chapter (section 1.9) to ensure clear sign-posting for the reader.

1.2 BACKGROUND

In April 2017, as the deputy team leader of an overland ice expedition to the North Pole, I was extracted with the team (with the film crew of the Amazon funded 'True North' film on cancer recovery and global warming) via a temporary Russian scientific Ice Station. On the 10^{th} April 2017, I met Alexander Danilov, a Russian climate researcher from the Arctic and Antarctic Research Institute (AARI) of the Federal Service for Hydrometeorology and Environmental Monitoring. As the AARI Deputy Director for Research, he expertly explained the background of the problem of climate change and shared a 'jaw-dropping' fact: that the NASA satellite images in February 2017 showed that there was 1 million square kilometres less ice around the North polar region, than in February 2016. This was the turning point for me. To stop talking about "the problem we need to resolve", and instead to "take action by leveraging my experience". The full explanation of the rationale of how and why I have come to the point of a doctoral project, based on my experience-led research, aligned to the Kolb Experiential Learning Cycle (1981, 1984), is provided in section 1.4, Personal Background.

1.3 CONTEXT – PROBLEM STATEMENT

In 2015, the international community responded to the sustainable development challenge with the Sustainable Development Goals (SDGs) for 2030 in their report 'Transforming Our World: The 2030 Agenda for Sustainable Development' (United Nations, 2015). The SDGs are the United Nations' blueprint and have been signed by 193 nations. They address the global challenges, such as poverty, inequality, climate change, environmental degradation, prosperity, and peace and justice. At the global level, the SDGs are interconnected, and the overarching ambition is to 'leave no one behind' in the achievement of the 2030 targets. However, the global nature of the SDGs means that they have a performance framework that is well developed at regional and national levels, but this has been difficult to cascade to the sub-national level, including at both the organisational and project levels (Patel et al., 2017; Galli et al., 2018). The problem manifests because most infrastructure investments are made at a local level, and therefore, without having an approach that makes adequate provision for the longer-term impacts across SDGs, there is a likelihood that practitioners will make less-informed decisions (Adshead et al., 2019; Thacker et al., 2019). Conversely, by using an SDG lens to view infrastructure investments, strategic infrastructure interventions can lead to significant SDG progress. This implies that improved decisions at local level are possible through translating global impact down to the project level.

Alarmingly, after only five years, the global commitment to deliver meaningful SDG action is falling behind on ambitions at both the local and global levels (Office of National Statistics, 2019). This is relevant for project managers because much of tomorrow's resilience and development will be delivered by the project management community, across all sectors, but especially infrastructure. More specifically, the IPCC's 2018 Report identifies that '*directing finance towards investment in infrastructure for mitigation and adaptation'* is key to meeting SDG targets. The estimated $97.5 trillion USD (Global Infrastructure Hub, 2019) of investment in infrastructure projects that is required globally by 2040, is considered by McKinsey Global Management Consultancy (Bielenberg et al., 2016) to represent a unique opportunity to stimulate economic prosperity, reduce poverty and raise standards in health, education and gender equality. At the same time, the challenge of measuring project outcomes against SDG goals, targets and indicators within existing project business models is not a new phenomenon, since the difficulty of measuring sustainability outcomes is a well-researched area (Proctor et al., 2011; Boswell et al., 2015). The use of SDGs to measure success at project level is important for two reasons: firstly, they can help monitor progress at an international level (Constanza et al., 2016); secondly, they can help with selecting infrastructure projects which aim to address SDGs in the design stage/front-end of projects (Adshead et al., 2019). In turn, investment decisions can be targeted towards the distribution of funding to infrastructure projects that can achieve broader and longer-lasting impact (Thacker et al., 2019). Up until this point, scientists, policymakers and practitioners seem to have captured the greatest challenges that the world is facing. The UN's recent fourth report on Localizing SDGs (Global Task Force, 2020) has amplified more than ever before the need to find new ways to increase the pace and scale of positive change post-COVID-19 pandemic. This has also been noted by others who have highlighted the need for new thinking on governance models which address the UN SDG priorities as well as for new ways to measure and support the delivery of the UN SDGs 2030 targets (Adshead et al., 2019).

1.4 PERSONAL PERSPECTIVE – ADOPTING THE KOLB LEARNING CYCLE

The author is typically central to research, so it is critical to reflect on my[1] own position to place my research in the context of my experience and motivations. My interest in this research subject was shaped by both my practitioner and research backgrounds. In this way, I have used the Kolb's (1981, 1984) Experiential Learning Cycle theory to help structure my approach across the four stages: Concrete Experience; Reflective Observation of the New Experience; Abstract Conceptualization; and Active Experimentation.

Over the course of my professional life, I have become increasingly involved in senior project management roles, in what Kolb describes as 'Concrete Experience'. By completing three master's level degrees at King's College London, Cambridge and Oxford Universities, I have been able to meaningfully apply the four Kolb learning stages with opportunities to reflect on new experiences, seek abstract

[1] The personal pronoun has been used in this section as it provides my personal perspective.

conceptualisation and apply active experimentation to see what effects the new action achieved.

I am not short of opportunities to apply this approach because I am one of UK's most senior project management advisors, as well as having personally led a number of national programmes, such as the Programme Director for Smart Meters. As such, I regularly represent the HM Treasury and the Cabinet Office as their Team Leader in reviewing and advising on UK's top megaprojects, as defined by Flyvbjerg (2009), often costing the taxpayer in excess of £1Bn and longer than 10 years in delivery and also, identified as critical to UK's infrastructure strategy (although I have led the review of many larger projects, with some megaprojects over £100Bn, including High Speed 2 and the UK Nuclear Deterrent). I regularly write reports for Ministers on project assessment reviews and I am responsible for recommending whether these projects should continue or be stopped. For example, I have been the government's senior advisor on full time consultancy roles to High Speed 2 Railway and also for the national post-Grenfell buildings response, for 26 of the 30 months prior to starting the doctoral research. I have also been on the United Nation's list of senior Governance Advisors, since 2012, for their largest and most complex Infrastructure Projects (UNOPS) which complemented my roles in the Ministry of Defence where I had worked extensively abroad, completed an MPhil at Cambridge University in International Relations and served for 3 years in the British Embassy in Washington DC. However, despite having a key part in the advice to Ministers and senior civil servants to drive improved performance, too often the megaprojects exceeded cost, were delivered outside time estimates and fell short on scope and benefits realisation. This underperformance challenge, noted by Flyvbjerg and colleagues (2003) as: '*the past decade has seen a sharp increase in the magnitude and frequency of major infrastructure projects ... the paradox being ... that many projects have strikingly poor performance records in terms of economy, environment and public suppor*t'. This failure has also been identified by many others through their examination of megaprojects such as Terminal 5 (Davies et al., 2009; Denicol, Davies & Krystallis, 2020). For this reason, it is one of the Cabinet Offices' highest priorities to resolve. It is repetitively wasteful and needs addressing.

My frustration with the consistent underperformance of megaprojects led me to complete a MSc in Major Programme Management at Oxford University between

2010-2012, under the mentoring of Professor Bent Flyvbjerg, a leading expert in this field. Whilst at the Said Business School, where I achieved the second highest marks on a course of 55 students and awarded a distinction, I set-up a charity (OxAid) with MBA students to provide *pro bono* support to global charities. In my first year we won two national project management excellence awards, and this led me to choose a research dissertation that sought to understand why environmental megaprojects were often poorly defined and inadequately reported against. I was given full access to all Worldwide Fund (WWF) for Nature's project data, for whom I had worked for 12 years on a pro bono basis and worked with them to identify whether their approach to the definition of outcomes and benefits was sufficient to deal with global challenges such as the impact of climate change. Sadly, my WWF research concluded that the greater the ambition of the project goal, the less likely the project delivered successfully. The research left a number of unanswered questions, including whether there was a better way to measure impact, in essence, becoming more adept at managing outcomes and less project output focused. Whilst the overall conclusion was not ground-breaking, some of the tools and approaches proposed added significant contributions to practitioners.

Since the completion of my MSc at Oxford I have continued my passion for project management by teaching at University College London (UCL) whilst also managing a busy professional advisory company, that won the Association of Project Management's top project management company in UK in two of its first five years in existence. In my final year of this doctoral research, I have completed my seventh year of lecturing at UCL, where I lead the UCL Strategic Management of Projects MSc's module on Governance and Controls at the Bartlett School of Construction and Project Management. This teaching has complemented my practical project management advisory work, fully embedding the benefits of the Kolb Experiential Learning Cycle (1981; 1984) and has further stimulated my desire to continue my research into measuring megaproject impacts.

More recently I have been working for the government as the senior Team Leader reviewing the Foreign and Commonwealth Office's investment of £1.2Bn into the Prosperity Fund[2] that seeks to address the UN's Sustainable Development Goals (SDGs). This work highlights the importance of investing smartly in projects that deliver the biggest 'bang for the buck' at a local level, but with impact that can be measured at the global level. I have also become closely involved with the Institution of Civil Engineers to consider how engineering companies can increase their infrastructure projects' impact on SDGs.

With my background in project management and an increasing interest in how to measure the local impact using global SDG goals, I was excited at the prospect of focusing on doctoral-level research to delve much deeper into this topical area. My discussions led me to a number of universities, such as UCL and Oxford University, where leading academics were generous in their offers for me to study with them. However, at LSBU I had particularly rich and fruitful discussions with Professor Rao Bhamidimarri, who led the Nathu Puri Institute (NPI) for Engineering and Enterprise, as well as the Knowledge Director at the Institution of Civil Engineers, Nathan Baker, who jointly offered me the opportunity to deliver the primary empirical research into the ICE's 200th celebration at their Global Engineering Congress with over 3,500 delegates. This gave me an 'open-door' to harness empirical evidence by surveying their members and also interviewing 40 CEOs from member organisations. Together, the ICE and LSBU agreed to sponsor me to research '*Measuring Infrastructure projects Sustainable Development Goals Impact' (MISI), by 'Thinking Global – Acting Local'*. The research would identify how engineering firms are equipping themselves better to deal with complex infrastructure project delivery that impact global Grand Challenges such as climate change.

In summary, the many megaproject failures that I had witnessed, as well as the growing need to address megaprojects to deal with Grand Challenges such as climate change, provided a rich area of potential research. At the commencement of my doctoral studies, I found strong evidence that this was a research area that mattered to practitioners and many of the global construction companies. There was evidence of a desire and need, but a gap between 'knowing and doing'. As I explored the literature,

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[2] In 2018-9, the Prosperity Fund included a portfolio of 27 multi-year programmes totalling £1.2 billion across a range of areas, including investment in infrastructure and aims to demonstrate how programmes contribute to the United Nations' Sustainable Development Goals (SDGs).

I discovered that whilst the appetite for knowing how to deliver local infrastructure projects to achieve global goals was highly valued, very few had mechanisms, processes or tools to do so. Thus, my doctoral studies developed from a growing awareness of the dissonance between what was wanted (a better way to measure local infrastructure investment decisions against global goals) and what was known about how to do it.

1.5 RESEARCH GAP, AIM, QUESTIONS AND OBJECTIVES

The relevance of this research is that finite resources must be invested to produce the 'biggest bang for the buck'. For example, in UK, around £640 billion of gross capital investment (UK HMT, 2020) is planned for infrastructure systems by 2024-25, in line with the National Infrastructure Strategy (2020). The critical point in relation to the challenges of climate change and other existential threats is how these infrastructure investments can deliver environmental, economic and society benefits, whilst contributing to the delivery of the SDG targets.

1.5.1 Research Gap and Purpose

The literature review in chapter two identifies that there is a **research gap** into 'How UN SDG impacts can be measured at project level'. It is an important question to answer because whilst the goals and targets are set at global and national levels, the delivery and impacts are at local level. The research to-date has not addressed this area (Økland, 2015) and therefore this new research provides an opportunity to test emerging theory-driven models with practitioners in the 'front-line' of project delivery. Simply stated, there is evidence that there is a great deal of 'greenwash' talk without confidence that measurement is either meaningful or verified.

Based on the research gap, the **purpose of the study** was to understand the practices of engineering organisations in the construction sector to Measure Infrastructure projects' SDG Impacts (MISI) in order to propose an improved prototype that provided a practical, value-add approach to MISI.

1.5.2 Research Question and Objectives

Based on the preceding discussion, the **research question** is: 'How can global SDG goals be used to define and measure infrastructure projects' SDG impact at organisational and local project levels?'. This question was answered through empirical research, assessing whether the current outcomes could be improved by the development of a theory-led prototype model that is workable at portfolio and project levels – the intent was that the mechanism would provide a practical way to link the definition of success of local projects, through the organisational construct (at portfolio level), to global SDG goals' impacts. Therefore, the eight **research objectives** cascading from the research question were:

- RO1: To understand the existing knowledge (in theory and practice) on how organisations and projects measure infrastructure projects' SDG Impact.
- RO2: To understand the context (the 'variables') of the current use of mechanisms to measure infrastructure projects' SDG Impact.
- RO3: To assess the current mechanisms used for the Measurement of Infrastructure projects' SDG Impact (MISI) at portfolio and project levels.
- RO4: To understand the perception of individual engineers and organisations' relative perception of the outcomes of the current use of mechanisms to measure infrastructure projects' SDG Impact.
- RO5: To use the theory-led study to inform the development of a prototype model to improve the measurement of infrastructure projects' SDG Impact.
- RO6: To test whether a 'golden thread' of SDG measurement could be identified from global to local levels.
- RO7: To test whether the prototype could be validated with a case study organisation.
- RO8: To build a framework for further development, for researchers and practitioners to utilise, driving improved investment decisions across planet, profit and people outcome criteria, aligned to SDG impacts.

The ROs sequentially support the design of the methodology (as shown in Chapter 4, Table 9), thereby providing findings and insights that iteratively inform the following study stage. This builds RO understanding cumulatively. The thesis will return to the RO in the final chapter when collating the summary findings across the four areas of: Research Objectives (were they achieved?); Variables Framework (the contextual and mechanism areas of study derived from Chapters 2-4); Propositions (derived from Chapter 2); and final Recommendations.

1.6 SIGNIFICANCE AND SCOPE

The contribution of this research is to harness the results of how engineers employ the SDG prototype framework at the project level to examine the 'contextual' strengths and weaknesses of utilizing the SDG measuring 'mechanism'. This provides deep insights for academics and practitioners to improve their understanding of how the SDGs can provide increased impact at the local level. It informs further research into local measurement of SDGs with, for example, the opportunity to assess theory-led investigations that establish a link from the local to global levels, via the portfolio layer. Practitioners can also learn from these developments, seeking new ways to link rhetoric to action (Scheyvens et al., 2016) so that businesses can fully leverage their innovation, responsiveness, and resources to drive SDG success.

The **scientific contribution** of the research is to provide insights for academics to further develop the theory-to-practice understanding of the Theory of Change (Weis, 2003) and its relationship to MISI. It provides an opportunity for researchers to compare their research with the specific context of this study and it adds evidence of a growing coherence to the development of the theories in specific contextual situations.

The **practical implications** are that the research into the specific contextual use of the prototype model by the Environment Agency highlights that it provides a workable approach for practitioner organisations to adopt, to strengthen their understanding of how to identify and measure prioritised SDG targets. In doing so, it enables a more balanced (across the TBL), longer-term, and plausible logic chain to align with existing business case and benefits management approaches. This provides confidence that the use of SDG targets can be used to improve, deepen and be made more relevant to individual projects' definition of success. This is pertinent at the key investment decision points to enhance the strategic clarity and stakeholder alignment by 'thinking global – but acting local'.

The **limitations** of the research are that the very essence of the Realist Evaluation (Pawson and Tilley, 1997; Linsley et al., 2015), the theoretical methodology used for this investigation, is the recognition that it is mostly contextually based and therefore extrapolation for theory and practice is not necessarily linear or binary. It is dependent on the social systems and agents that were part of this research at this particular time-context. It therefore acts as a basis for knowledge building in this important area.

1.7 THESIS OUTLINE

The **structure of the thesis** is as follows:

The **first chapter** provides an overview of the thesis and its component parts.

Chapter 2 provides a literature review which was aimed to ascertain the current understanding of construction sector's approach to Measuring Infrastructure Projects' UN SDG Impacts (MISI). The chapter, based on a detailed Systematic Literature Review (SLR) evaluates three topics, including: Grand Challenges and SDGs; Sustainability and Sustainable Development in relation to SDGs; and, Sustainable infrastructure projects and project success in relation to SDGs. It concludes by identifying the results and emergent themes from the SLR and its implications for shaping the research design.

Chapter 3 discusses the theoretical framework. The chapter describes how the Critical Realism perspective of ideological philosophers such as Bhaskar (1978) informed the Realist Evaluation approach championed by Pawson and Tilley (2004) and this introduces the Context-Mechanism-Outcomes model that provides the overarching research framework. The chapter includes analysis of the primary theories adopted for the research, including the Theory of Change and Triple Bottom Line, which are both embedded in the proposed mechanism, called the Impact Value Chain (IVC). The initial theoretical model of the IVC is developed synthesising the findings from Chapters 2 and 3. It is further developed into a prototype in Chapter 7, based on findings from the survey and interviews. The chapter also introduces the context and mechanism across the project organisational structure developed by Müller, Drouin, and Sankaran (2019a), who proposed a layered model of organisational project management (OPM). This enables the structured evaluation of the concept of SDG, from global to local, at portfolio, mega-project and project levels.

Chapter 4 outlines the research design and methodology for this Sequential Explanatory Design (Creswell, 2017) that uses a mixed methods study of surveys and interviews to address Proposition 1 and 2 (listed at the end of Chapter 2) – gaining insights to individual engineers' and organisations' perceptions of approaches to

MISI. A section on research design describes the philosophical position of the thesis and the research setting that is discussed in more detail in Chapter 5 for the survey, and the interviews in Chapter 6.

Chapter 5 addresses the survey method, its results and the analysis. It describes the sample size, data collection tools, procedure, and data analysis used. Data integration methods, strategies to minimise threats to validity, and ethical issues are described to end this chapter as well as identifying themes that can be utilized to inform the interview stage. It concludes by answering Proposition 1: The current SDG Goals measurement approach (process, tools and governance) at project level are relevant and reliable, as perceived by individual engineers.

Chapter 6 is similar in structure to Chapter 5, but instead, covers the interview method, its results and the analysis. It describes the sample size, data collection tools, procedure, and data analysis used. Interview findings begin with a rich description of the sample which is followed by detailed description of the findings presented in model format and supported by in-depth quotations. The chapter concludes by combining the emergent themes from both the survey and the interviews. It concludes by answering Proposition 2.

Chapter 7 captures the triangulation of results that informs the further (from Chapter 3's initial IVC design) development of the IVC from an initial theoretical model into a more robust prototype, ready for testing. This is done through the iteration of the IVC theoretical model that was initially synthesised from Chapter 2 and 3, described more fully in Section 3.8. In this chapter, the IVC is jointly developed with a methodology, the SDGiPro© (designed by the author alongside the IVC model) that had been identified from the survey and interviews as a necessary extension to the IVC to support its implementation in 'active' projects. This early prototype is developed to a stage that is ready for testing in Test 1 (SDG 'Golden Thread') and Test 2 (in a water utility company context), discussed in Chapters 8 and 9 respectively. In the chapter's conclusion, the approach to testing the IVC prototype model is discussed, leading to Test 1 and Test 2, discussed below in the summary of Chapters 8 and 9 respectively.

In **Chapter 8** the context of the 'Golden Thread' test is discussed. It describes the approach to the identification of the Global Reporting Initiative ('GRI' is the global standard for organisational ESG (Environment, Social and Governance) measurement.

It explains why the Building Research Establishment's CEEQUAL project sustainability measurement approach is jointly used with GRI to test the linkage from SDG, through the GRI, to the project-level assessments. Following this, findings stemming from the analysis are used to answer Proposition 3: A 'golden thread' exists from 'global' level SDG goals and targets, through organisational levels (e.g., portfolio), cascaded to 'local' project levels.

Chapter 9 outlines Test 2, the case study using the Impact Value Chain (IVC) in a water utility organisation. This links the organisation's strategic objectives (corporate goals) with SDGs and maps the pathway to measure the selected SDG goals at project level in the delivery phase. It describes the approach to the identification of the water utility company, Anglian Water, and the use of desk-level analysis of publicly available information and interviews with a few of the leaders, to assess the potential practical use of the IVC. Following this, findings stemming from the analysis are used to answer Proposition 4: A developed prototype, building on empirical findings from testing proposition' 1, 2, and 3 can provide a plausible, testable and achievable logic chain for defining project-SDG impacts. The final sections describe the strengths and limitations of this research.

Chapter 10 concludes the thesis with a summary followed by description of how this research contributes new knowledge. Implications for practice, future research, and policy are outlined. It includes summary findings across the four areas of: Research Objectives (were they achieved?); Variables Framework (the contextual and mechanism areas of study derived from Chapters 2-4); Propositions (derived from Chapter 2); and, final Recommendations. The chapter includes the implications for this research on the Theory of Change, through the IVC, on the MISI approach. It addresses potential value to the scientific and practitioner communities and shares the emergent results from the collaboration with the Environment Agency, Thames Tideway and the UK Government's Infrastructure and Projects Authority (with UCL, ICE, BRE and UN Global Compact – their letters of impact support are included at Appendices 17-23). The dissemination strategy is provided as well as reflections from the researcher using reflexivity, with concluding remarks to close the thesis.

The overall chapter structure for the thesis investigation is shown below:

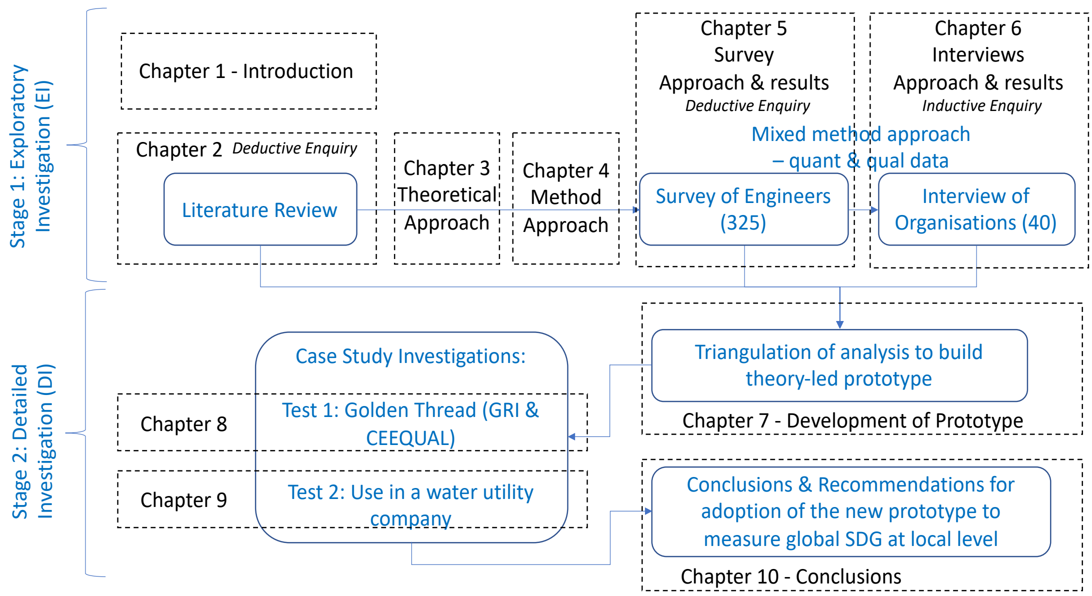


Figure 1: Thesis Chapter Map and Workflow.

Note: The LSBU Research Degree Code of Practice (2018), states the thesis should contain information on any publications produced as part of the research, "either included as part of the thesis or placed in a pocket at the end of the thesis" (Research Degree Code of Practice, p.24). The full list of peer-reviewed published papers (n=12) are shown at *Appendix 24 – Publications in Advance of Thesis.* Chapters 2, 5, 6, 7, 8, 9 were all developed from published papers in internationally leading journals including Sustainability (two articles), Administrative Sciences, and the Proceedings of the Institution of Civil Engineers–Engineering Sustainability. Copies can be provided on request (weblinks are included in Appendix 24).

1.8 SUMMARY AND LINK TO THE NEXT CHAPTER

This chapter provided an orientation to the thesis. SDGs are of fundamental importance to the global community – the macro effects are global in nature but have local impacts. The corollary is also true, that investing in infrastructure projects that have a meaningful SDG local impact, can contribute to global SDG goals for the benefit of the planet, profit and people.

The author's personal experience across project management and also as an Arctic and Antarctic explorer inform the research approach, using the Kolb Experiential learning Cycle. The thesis organisation across the 10 chapters is explained to orientate readers to its structure and content. The next chapter provides a review of literature relating to MISI.

The Logic Map shown below in Figure 2 illustrates the development of the structure and evidence-trail to respond to the Research Question and its Objectives. The map also depicts the development of the Propositions and the C-M-O Variables Framework. The red boxes and red connecting lines illustrate how this measurement framework was built and how it flows. It highlights the connecting loop, from the design of a comprehensive and evidence-based research structure, that returns to answer the Research Question and Objectives established in Chapter 1.

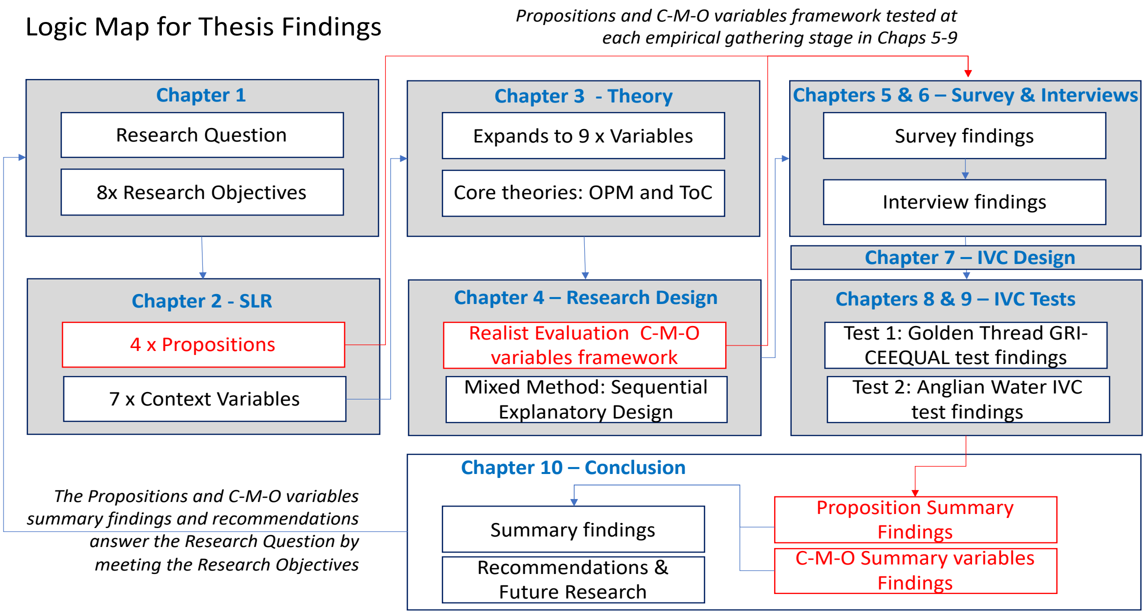


Figure 2. Logic Map of Thesis Findings (red line = Proposition & Variables Framework flow).

Chapter 2: Literature Review

2.1 OUTLINE OF THIS CHAPTER

The central topics of this chapter are: Topic 1, Grand Challenges and SDGs (Section 2.3); Topic 2, Sustainability and sustainable development in relation to SDGs (Section 2.4); Topic 3, Sustainable Infrastructure Projects and project success in relation to the SDGs (Section 2.5). This is followed by a description in Section 2.6 of the methodology employed for the systematic literature review, based on the PRISMA (Liberati et al., 2009) checklist, to investigate the existing UN SDG targets in relation to Infrastructure Projects (IP). In the concluding part of the chapter the preliminary findings from the systematic literature review are listed with a description of how they will inform the construct of the thesis' research framework, thereby providing an organised way to conduct the empirical data collection in Chapters 5, 6, 8 and 9.

2.2 LITERATURE REVIEW INTRODUCTION

This chapter reviews the published knowledge of the research area and provides arguments to support the study focus. The aim of this chapter is to delineate various theoretical positions, and from these, to develop a conceptual framework to underpin the research question. In order to meet the first three Research Objectives (Section 1.5.2)[3] there were three sub-research questions chosen to guide the SLR:

(1) How extensive (broad and deep) has the research into MISI been to-date?;

(2) What context and mechanism variables were identified that might inform the building of MISI study's 'Variables Framework'? This framework is developed in Chapters 2 and-4 and is used to help collate the findings in the final Chapter. They also support systematic research in the empirical data gathering stage (Chapter 6,7,8 and 9); and

(3) Subsequent to the doctoral MISI research, how could such a framework be used to provide guidance to a range of stakeholders (including regulators,

[3] RO1: To understand the existing MISI knowledge (in theory and practice); RO2: To understand the MISI context (the 'variables'); RO3: To assess the current MISI mechanisms.

policymakers, academia, investors and infrastructure practitioners) on how to align IP and their impacts to the SDGs?

2.3 *GRAND CHALLENGES AND SDG*

Grand Challenges is a term used, predominantly by the academic community, to qualify and structure responses to so called 'wicked problems' (Head & Alford, 2015) of immense magnitude and impact. 'Grand Challenges' capture ideas that are equally relevant to academics as well as practitioners. They are also, by definition, both ambitious ("capture the peoples' imagination") and achievable ("solve … problems") (Executive Office of the President, 1989). Additionally, the definition identifies the need for impact and the measurement thereof and impact to demonstrate meaningful progress. The definition of Grand Challenges has evolved since Mertz's (2005) focus on the engineering communities, to a broader group of stakeholders that includes policy shapers, funders, and delivery-to-operations project teams (Omenn, 2006). Consequently, project management professionals have the opportunity to take a leading role in this, especially in providing tangible action that can be implemented by practitioners to effect improved performance against the SDG targets.

More recent research into Grand Challenges (Sakhrani et al., 2017) has identified five characteristics that are helpful in this paper's MISI analysis: Grand Challenges are (a) articulated by stakeholders, (b) specific, (c) ambitious yet feasible, (d) framed in a manner that suggests the use of specific methods or disciplines, and (e) have the potential for broad impact. These characteristics provide a useful reference point for developing a conceptual framework to deepen the research into how the project management community can define, design and measure IP contributions towards the SDGs. In effect, the characteristics of the five grand challenges provide the 'lens' to identify what links SDGs to IP.

The failure of not meeting the 2030 targets of the United Nations Sustainable Development Goals (hereafter, UN SDGs) is amongst the most significant global Grand Challenges threatening our survival today (IPCC, 2018) and there is the potential for the project management community to play a key part (Morris, 2017) in making a positive impact on the 2030 targets, as illustrated in Figure 3.

Figure 3: The Global Goals for Sustainable Development (United Nations 2015—permission to use from Sustainable Development Goal (SDG) logo Guidelines).

Although the SDGs build on the earlier Millennium Development Goals (MDGs) by focusing on similar issues, the SDGs differ from the MDGs because they are for all countries in the world to implement—developed and developing alike. Moreover, unlike the MDGs, the SDGs are focused on monitoring, evaluation and accountability across society, not just at the national level, which is why it is critical that the link is made from the 'bottom-to-top'. This means linking from the delivery at the local project level through to the impacts at the national and global levels. However, there appears to be a gap. The golden thread from the national to the project level seems to be missing. This is key because SDGs have been conceptualised at the global level but actually materialise and are operationalised at the project level (Thacker et al., 2019). This is especially true for infrastructure projects (IP) (Adshead et al., 2019) that often reflect large-scale governmental investments, which are delivered by multiple stakeholders working across boundaries and where the linking of global-to-local impacts at the project level is potentially transformative for business policy and everyday citizens, as discussed in the next section.

The SDG delivery targets are understandably ambitious and needed a reporting framework that would drive meaningful and verifiable progress towards the 2030 targets. In 2017, the UN's Inter-agency Expert Group on Targets and Indicators for Sustainable Development designed a mechanism that linked goals, targets and indicators across the geographic and governance boundaries at national, regional and global levels (IAEG-SDGs, 2017). Within this framework, shown in Figure 4, the

Expert Group designed thematic areas that could also be used at the subnational level but, because the targets and indicators were originally designed to be used at global, regional and national level, they had reduced applicability at organisational or project levels. Simply stated, “one size does not fit all”. This provides a significant challenge because most of the investment needed (USD $94 trillion) to respond to the global goals (Global Infrastructure Hub, 2020) is delivered through the business sector, typically through infrastructure projects, which contribute to the systems and services that can positively impact health, wealth and inequalities.

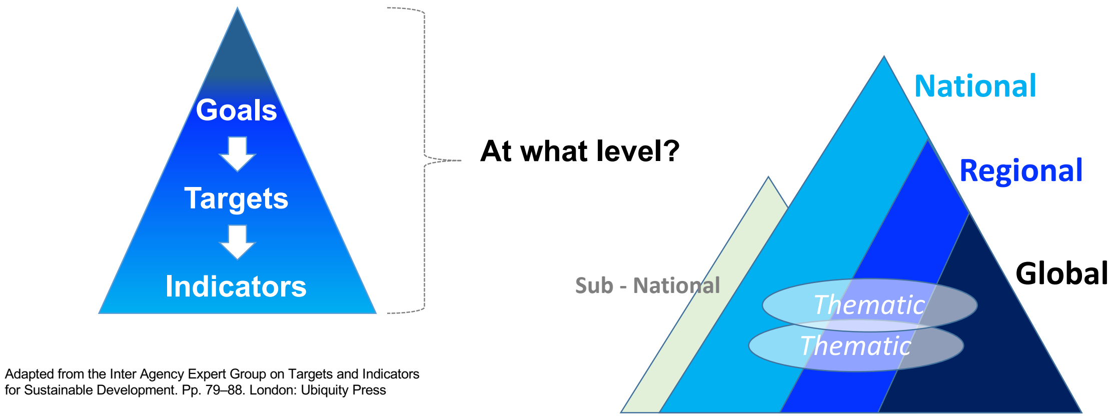


Figure 4: The sustainable development goals (SDG) Targets and Indicators’ framework designed by the UN IAEG-SDGs (2017).

As stated earlier, the SDGs consist of 17 major goals and 169 concrete targets and, because some of the targets are not expressed as concrete numbers, the UN also developed a framework of 232 indicators for monitoring and reviewing the targets. Research into the use of the SDG framework (Mansell et al., 2019a) on infrastructure projects has identified that the targets (N = 169) and indicators (N = 232) are too numerous and complicated and therefore, unfortunately, they are rarely used by engineering and project practitioners. The research concluded that a new way was needed to reduce the scientific and statistical complexity of the SDG measurement framework. The starting point for this approach was to evaluate their usability and applicability at the project level on a sector-by-sector basis. For example, in the infrastructure sector, recent analysis (UNOPS, 2018) indicates that 81% of the SDG targets are influenced by infrastructure investment projects. However, “influence” is a comparatively weak word without specifying “attribution” (i.e., directly impacting with verifiable evidence) or “contribution” (i.e., linkage presumed but without evidence) and, therefore, despite the positive conclusion from the UNOPS’s analysis

(2018), further research is needed to identify which of the SDG targets can be used at project level.

2.4 *SUSTAINABILITY AND SUSTAINABLE DEVELOPMENT IN RELATION TO SDG*

Sustainability can be a challenging word. Indeed, fifteen years ago there were up to sixty definitions of sustainability (Hartshorn et al., 2005) with little convergence of how the theory of sustainability could be given meaning in practice. There are those (Zuofa, & Ochieng, 2016; Sverdrup & Rosen, 1998) who suggest that sustainability is essentially the long-term harnessing of an ecosystem to maximise the outcomes whilst ensuring the extraction of the input of resources from the ecosystem do not negatively impact its long-term viability. Alternatively, there are others (Costanza & Patten, 1995) who define sustainability simply as a measure of whether a system can ultimately continue or is self-consuming. Holling (2001) broadened the sustainability systems' definition to include 'development': "Sustainable development … refers to the goal of fostering adaptive capabilities and creating opportunities". It can thus be shown that 'sustainability' has become mired in value-laden language and often vague in concept (Mebratu, 1998; Ciegis et al., 2009; Emas, 2015) that can cause diffusion of interpretation and confusion in practice (Fenner et al., 2006; Ainger and Fenner, 2014; Moore et al., 2017). These examples explain why the definition remains nebulous and why a practical definition has greater utility (Glavic and Lukman, 2007) for project managers.

Salas-Zapata and Ortiz-Muñoz (2019) consider four uses and meanings of the concept of sustainability: (1) a set of criteria, consisting of social-ecological criteria to guide human actions or their products; (2) a vision or goal, which is the convergence of environmental, social and economic purposes, expectations, aims or goals of a system; (3) an object, which is an empirical entity that can be thought and intervened; and (4) an approach, which is the study of social, economic and ecological dimensions or variables of a human activity, product or system.

For the purposes of this thesis, the definition of sustainability builds on the broader definition of sustainable development as "development that meets the needs of the present without compromising the ability of future generations to meet their own needs" (Brundtland, 1987). Over the past 50 years, the phraseology and understanding of ‘sustainable development’ (Sachs, 2016) has become an increasingly central theme of nation states and their citizens. Today, the Planetary Boundaries (Rockström, 2009; De Vries et al.2015) provide a global litmus test for how we are doing. The concept of nine planetary boundaries within which humanity can continue to develop and thrive for generations to come was developed in 2009 by environmental scientists from the Stockholm Resilience Centre. The most significant global response to the Planetary Boundary challenge was in 2015, when all governments ratified the UN’s 17 SDGs (United Nations, 2015) to be achieved by 2030. This represented a major step-change in the implementation of the sustainability agenda and effective responses to the Planetary Boundary challenge (Rockström, 2009).

It is opined that a gap exists – Infrastructure Projects (IP) are not included in the SDGs’ measurement, and the evidence (Martens, & Carvalho, 2016a and 2016b) illustrates that the golden thread from project level measurement to global-national level, is missing. This echoes research highlighting a gap between theory and practice for incorporating sustainability measurement in project management (Økland, 2015).

The problem of identifying suitable SDG measurement is compounded at the indicator level, where a further 232 measurement metrics reside. For example, the UK’s Office for National Statistics (ONS) online portal, responsible for reporting UK’s progress against global SDG indicator measurement, shows that, in April 2019, they only had data for 173 of the 232 indicators, with 69 being without data (ONS, 2019). The ONS’s challenge of collating reporting evidence for the 232 indicators was further corroborated by recent analysis (Mansell et al., 2019a) of the viability of using each of 232 indicators for infrastructure project-level measurement of success. The analysis, based on inductive reasoning using the project success framework proposed by Morris (2013) and Cooke-Davies (2007) and then analysed against the cost-benefit measurement framework from the HMT Green & Orange Books (HM Treasury, 2013) and the World Bank monitoring, reporting, evaluation and learning methodology (Dudwick et al., 2006), highlighted there were only a small number of indicators (N = 28; 12%) relevant to engineering projects. Of these, only 8% (N = 20) have close alignment with the engineering projects and 4% (N = 8) have marginal relevance. This analysis highlighted a “gap” of not having suitable indicators below the SDG target level that could be used on infrastructure projects.

2.5 *SUSTAINABLE INFRASTRUCTURE PROJECTS (IP) AND PROJECT SUCCESS IN RELATION TO SDG*

The Global Commission on the Economy and Climate defined Infrastructure (New Climate Economy 2016, p. 4) as ‘structures and facilities that underpin power and other energy systems (including upstream infrastructure, such as the fuel production sector), transport, telecommunications, water, and waste management’. This definition takes a systems perspective and includes energy, transport, buildings, water supply and sanitation, IT and communications, but does not explicitly include natural infrastructure such as forests, deserts, wetlands and other ecosystems (Bhattacharya et al. 2015; The New Climate Economy 2016).

Most of society’s developments in recent times can be connected to infrastructure projects (Thacker and Hall, 2018; Thacker et al., 2019) and the UN recognise that the development of infrastructure represents a massive opportunity to stimulate economic prosperity, reduce poverty and raise standards in health, education and gender equality (UNOPS, 2018).

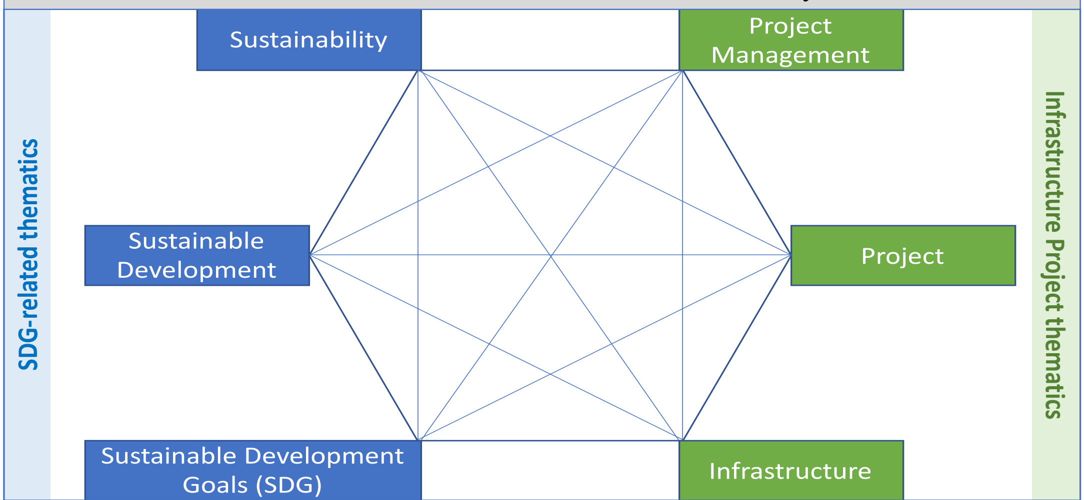
It is evident that ameliorating many of the risks associated with grand challenges, such as climate change, can be supported through investment in appropriate and resilient infrastructure and engineering (OECD, 2019). For example, greenhouse gas emissions cannot be sufficiently reduced without new forms of energy infrastructure or less polluting transport networks; and water security requires investment in new and more resilient forms of water infrastructure (OECD, 2019; United Nations, 2019). This highlights the importance of IP to link from the local investment level to global goals and perhaps provides recognition of the ability of engineering and infrastructure to reduce strategic business risk.

Contribution to the growing literature on the measurement of IPs on sustainability is provided by Shen, et al. (2010), who focus on the balance needed between benefits to society whilst protecting the environment and still achieving the economic benefits envisaged in the project business case. The linkage across the three areas in the construction industry is further defined by Kibert (2013), who suggests the interrelationship between a project’s outputs and the society that is impacted is a central component of defining sustainability success of an infrastructure project. This introduces the concept that project success definition needs to consider success against the Triple Bottom Line (TBL) (Elkington, 1994) of social, environmental (or ecological) and economic (or financial) effects, otherwise noted as the ‘Three Pillars’ concept of ‘people, profit and the planet’ (Elkington, 1994, 2018; Griggs et al, 2013).

Defining IP success is central to the understanding of how to link global-national level SDGs with local IP because it allows stakeholders to align their expectations against shorter-term outputs as well as the longer-term outcomes and SDG impacts. More recent research into project success definition (Thiry, 2004; Lavagnon, 2009; Jenner, 2016) has consistently identified benefits and outcomes as being a critical determinant for the assessment of project success. For example, Michael Thiry (2004) highlights that ‘too many critical success factors are related to inputs and management processes and not enough on outcomes’. This is further supported by those (Morris, 2013; Terry Cooke-Davies, 2002, 2007) who identify three levels of success criteria: project management success – was the project done right?; project success – was the right project done?; and consistent project success – were the projects done right, time after time?

Based on the specific sub-research question of this systematic literature review and the earlier exploration of the key thematic areas, the following systems map at Figure 5 was developed to guide the choice of methodology, based on the 6 core areas that are all linked as a systems-of-systems map. This demonstrates their interconnections and the basis for the chosen research approach.

Which MISI research thematics are central to the study’s SLR?



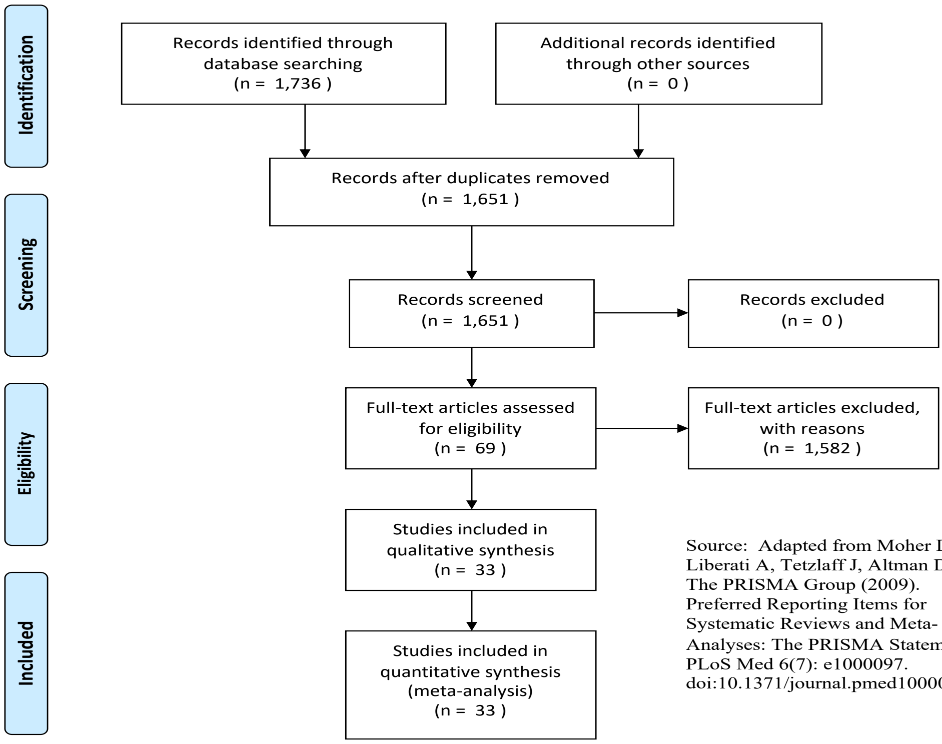
(1) How extensive (broad and deep) has the research into MISI been to-date?;
(2) What issues and context variables were identified that might inform the MISI study’s thematic framework to support more systematic research in the empirical data gathering stage (Chapter 6,7,8 and 9)?; and (3) Post this doctoral MISI research, how could such a framework be used to provide guidance to a wider range of stakeholders on how to align IP and their impacts to the SDGs?

Figure 5: Systems map showing the key thematic areas related to the research question.

2.6 METHODOLOGY FOR LITERATURE REVIEW

In order to meet the first three Research Objectives (Section 1.5.2)[4], it was decided to conduct a systematic literature review (SLR) focused on the leading journals that publish articles across the three thematics of business policy, sustainability and project management.

A literature review can broadly be described as a systematic way of collecting and synthesizing previous research (Baumeister & Leary, 1997; Tranfield, Denyer, & Smart, 2003). The selected approach conformed to established SLR protocols that have been mostly based on the rules and standards proposed by Liberati et al. (2009). In development of the PRISMA statement, the researcher (Liberati et al., 2009) laid out a reporting proposal for systematic reviews that had been derived from the meta-analyses of health care studies. As part of this work, the study developed a 'PRISMA Flow Diagram' (Moher et al., 2009) that explains and elaborates on the PRISMA Statement. An example of how this approach was used is shown in the adapted flow diagram, below:



Source: Adapted from Moher D, Liberati A, Tetzlaff J, Altman DG, The PRISMA Group (2009). Preferred Reporting Items for Systematic Reviews and Meta-Analyses: The PRISMA Statement. PLoS Med 6(7): e1000097. doi:10.1371/journal.pmed1000097.

Figure 6: Adaption of the PRISMA Flow Diagram' (Moher et al., 2009) to explain the de-selection process.

[4] Shortened RO: RO1: To understand the existing MISI knowledge (in theory and practice); RO2: To understand the MISI context (the 'variables'); RO3: To assess the current MISI mechanisms.

This was complemented by a Level 2 Analysis that adopted a semi-systematic review process, advocated by Wong et al. (2013), that evaluated the top 13 articles that had the highest prevalence of keywords within the selected dataset, and this supported the derived nodal map of key variable that provided a evidence-based MISI 'Variables Framework' to be studied. These approaches are shown diagrammatically in Figure 7.

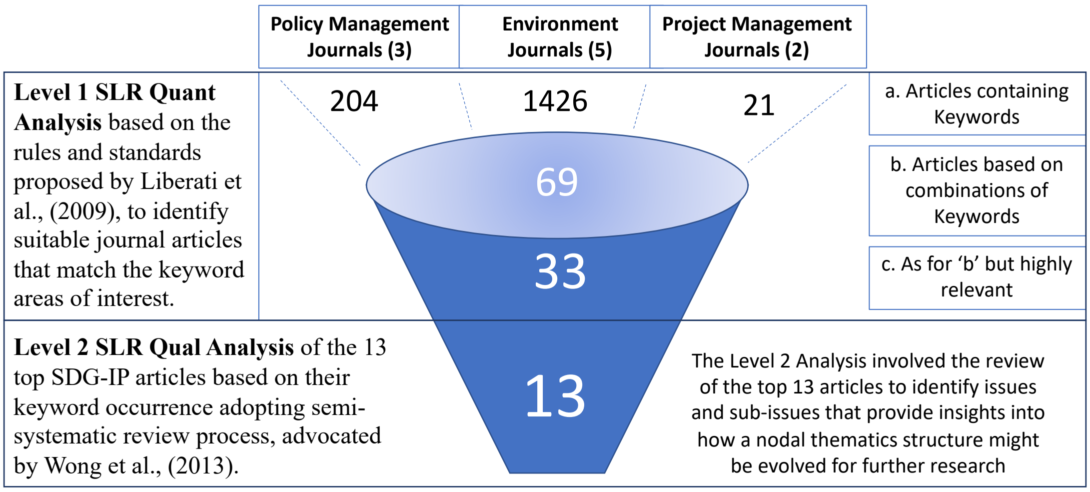


Figure 7: The 'hopper' approach to SLR Level 1 and 2 Analysis

With an aim to ensure sufficiently comprehensive coverage across the three thematics (of business policy, sustainability and project management), the focus of the review was on: project management related journals (International Journal of Project Management, and Project Management Journal); sustainability related journals (Journal of Cleaner Production, and Sustainability); and policy related journals (Journal of Environmental Management, Business Strategy and the Environment, Environmental Science and Policy, Research Policy, and Global Environmental Change). Combined, these journals publish the representative coverage of academic research across the three thematics of project management, sustainability and business policy.

In order to assemble the dataset, Scopus[5] was used as the search engine, identifying articles by source types (peer-reviewed articles within the selected

[5] The doctoral researcher had support from an assistant at Cape Town University, operating within the design and framework set by the lead researcher. The specific work carried out by the research assistant included: collection and initial analysis of all selected articles from Scopus; collation of data in spreadsheets; stand-in for lead researcher at EPOC Conference to present findings, October 2020 - https://epossociety.org/epoc-2020-website.

journals). As part of the search, the following keywords were used: ‘sustainable development goal’, ‘sustainable development’, or ‘sustainability’ in conjunction with ‘project’, ‘project management’ or ‘infrastructure’ (from 2015 to 2020). The choice of the six keywords was based on clear differentiation of SDG and IP terminology as well as the need to limit the selection to a manageable data size for analysis. These keywords were searched within the fields of ‘title’, ‘abstract’ and ‘index key words’ as defined by the Scopus search engine. This yielded 1,651 articles, shown in the table below (as oft February 2020).

Table 1: Items containing keywords, in the database per Journal

Journal	Total
Journal of Cleaner Production	433
Journal of Environmental Management	366
Sustainability (Switzerland)	376
Business Strategy and the Environment	214
Environmental Science and Policy	162
Research Policy	40
Global Environmental Change	37
International Journal of Project Management	17
Project Management Journal	4
Journal of Social Policy	2
	1,651

The occurrence of searched keywords in relation to one another is displayed in in respect of the title, abstract and index key words (see Table 1). Duplications of items containing a combination of more than two keywords were resolved.

Table 2: Items containing combinations of keywords

	No. of items		
Search keywords combinations across the title, abstract and index key words	**Title**	**Abstract**	**Index**
“SDG”/"sustainable development goal" + "project"	0	47	0
“SDG”/"sustainable development goal" + "project management"	0	0	0
“SDG”/"sustainable development goal" + "infrastructure"	2	27	0
"sustainable development" + "project"	10	163	153
"sustainable development" + "project management"	1	12	78
"sustainable development" + "infrastructure"	5	89	65
"sustainability" + "project"	53	395	129
"sustainability" + "project management"	10	43	76
"sustainability" + "infrastructure"	17	227	100

“sustainable infrastructure”	11	17	6
Total items	**109**	**1,020**	**607**
Total	**1,736**		

Table 3: Data analysis of key words tabulated across the two dimensions of SDG and IP.

Data capture in **Title**	**Project**	**Project Management**	**Infrastructure**
SDG/Sustainable Development Goal	0	0	2
Sustainable Development	10	1	5
Sustainability	53	10	17
Data capture in **Abstract**			
SDG/Sustainable Development Goal	47	0	27
Sustainable Development	163	12	89
Sustainability	395	43	227
Data capture in **Index Key Words**			
SDG/Sustainable Development Goal	0	0	0
Sustainable Development	153	78	65
Sustainability	129	76	100

To filter out less relevant articles from the sample, a subset was created based on the occurrence of the combinations of keywords, in both title and abstract, as represented in Table 4. The resultant abstracts were browsed for relevance, which eliminated numerous articles (most of which were focused on pedagogies and training around sustainable development goals, or sustainability projects and initiatives in non-infrastructure sectors).

Table 4: The resultant reduction of dataset based on combination of keywords

Subset Delineators: Combined Keywords	**Total Items**	**Relevant Articles**
SDG/Sustainable Development Goal + Project	42	12
SDG/Sustainable Development Goal + Infrastructure	22	16
SDG/Sustainable Development Goal + Project + Infrastructure	5	4
	69	**32**

The 33 articles represent the final subset analysed. These were included in the final review dataset that followed the SLR approach adopted by Jarvis et al. (2003) that codifies data using relevant thematic frameworks, which was based on the SDG IP thematic structure, codifying key information in relation to seven areas of interest:

- Type of contribution (such as framework proposition, framework testing, exploratory, theoretical, etc.).

- Research design (namely, empirical, single/multiple case study, systematic literature review, etc.).
- Primary geographical focus of study (i.e. where the study was focused).
- Primary infrastructure sector (e.g. water, energy, transport, etc.).
- Primary industry (if applicable; e.g. airports).
- Relevant institutional level (e.g. regional, national, organisational, etc.).
- Sustainable Development Goals mentioned in the article.

The summary data across the 33 articles codified against the seven MISI thematics is included at Appendix 1. The results from this analysis are captured and discussed in the following section. The analysis has been completed at two levels: level 1 examines the dataset of 33 articles across the seven MISI thematics and level 2 provides a deeper analysis of the 13 most relevant articles, based on their prevalence of keyword combinations, across MISI research issues and themes.

2.7 RESULTS AND DISCUSSION OF THE SLR

2.7.1 Quantity of Relevant Articles in Dataset

The analysis of the dataset, illustrated in Figure 8, showed that within the 1600+ sample, there were identifiable differences and similarities. For example, across the four sustainability journals there was a total of 1,426 articles which equates to 285 articles per sustainability journal. This compares with a total of 204 across the policy journals. The least represented were the project management journals that had a total of 21 articles.

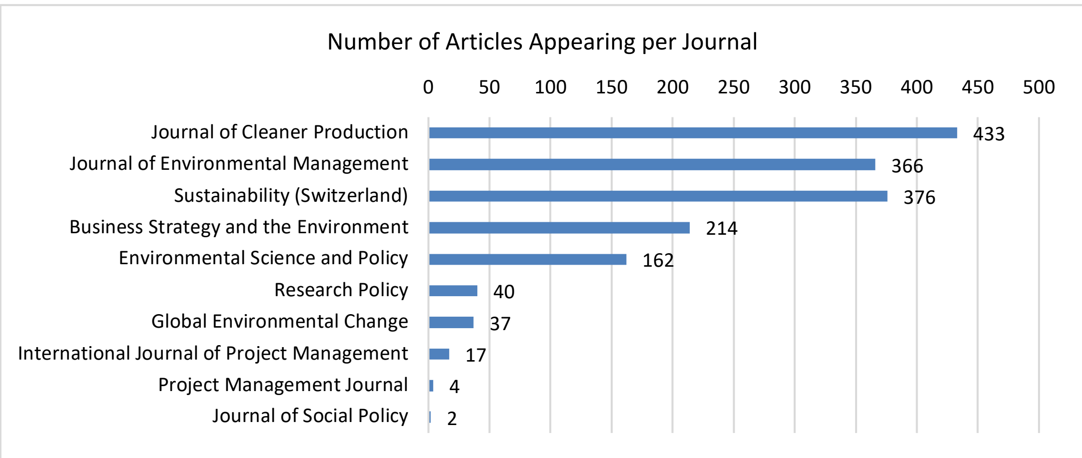


Figure 8: Occurrences of articles appearing in selected journals using the keywords

2.7.2 Quantity of Use of Keywords in Abstracts over time

The dataset enabled the capture of the prevalence of keywords used over the selected time period of 2015 – February 2020, as shown in Figure 9. The value for researchers in this field is that it highlights the rapid increase in some keywords, especially in the past two years, and suggests that this is an increasing area of importance and relevance. For example, the prevalence of 'SDG' has increased by a factor of 29 with most of the increase in the last two years. Similarly, the appearance of the keywords of 'sustainable development' have increased by a factor of five and 'sustainability' by a factor of three. The latter two keywords have also had a noticeable inflection point in 2017, that is most likely due to the increasing recognition of the SDG terminology since their introduction in 2015.

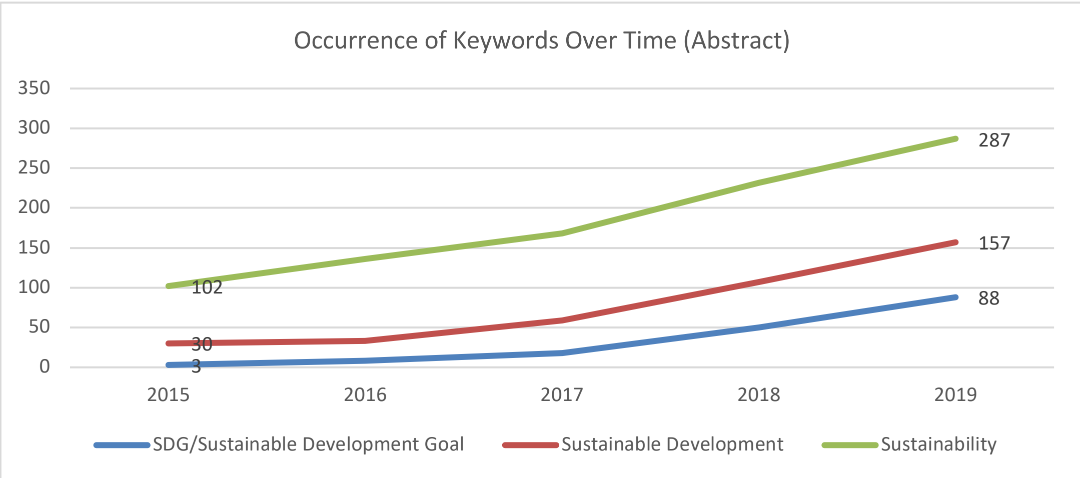


Figure 9: Occurrence of Keywords in abstracts over time

2.7.3 Level 1 Analysis - Results across the seven codified MISI thematics

This sub section covers the analysis of the seven SLR research areas identified in the earlier part of this SLR.

2.7.3.1 MISI Related Research Finding 1: Type of contribution (framework proposition, framework testing, exploratory, theoretical, etc.)

Since the aim of this chapter was to evaluate the state of knowledge on the specific MISI research, it is useful to identify what approaches have been used to evaluate this area. The purpose was to create relevant MISI research framework, based on any identified gaps in research, or seek insights that facilitate the empirical data gathering such as through the design of the survey agenda (Chapter 5) and the interviews (Chapter 6). In this way, it has been proposed (Baumeister & Leary, 1997; Torraco, 2005) that literature reviews are useful to develop theory and conceptual models, as completed in Chapter 3 (Theory) and Chapter 7 (Development of the prototype model).

Figure 10: Type of contributions, using a hierarchical tree map chart, across subset.

The results showed a pre-dominance (60%) of articles were based on Framework Testing (in this context a framework means an analytical tool to support a research study) and Framework Propositions, but there were fewer Theoretical articles and Exploratory methods. This might suggest that there is less confidence in existing theories, and that new frameworks are being developed to harness the theories more effectively for the emerging demands of the MISI topic. While there is not necessarily a MISI research gap in the type of contributions, the findings might highlight the preference for frameworks as a way to engage with practitioners that are seeking tools to effect improved ways of measuring SDG impacts on IP.

2.7.3.2 MISI Related Research Finding 2: Research design (empirical, single/multiple case study, systematic literature review, etc.)

The analysis of MISI SLR research finding 2 on research design used the five headings (shown in Figure 11) to give a high-level quantification of design use. This illustrates that empirical analysis was the most favoured approach, and that two thirds of articles used case studies in some form.

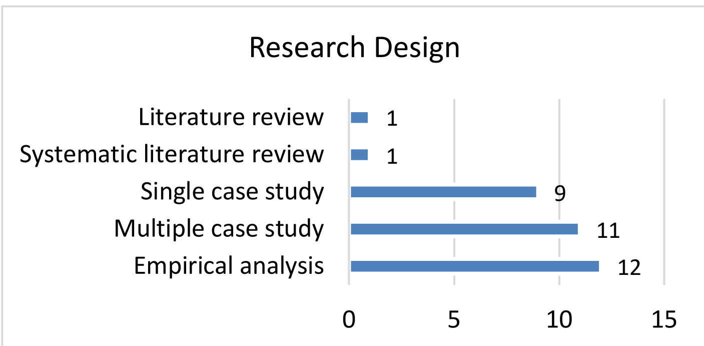


Figure 11: Research design approaches.

The results showed that empirical analysis was the favoured approach followed by multi-case studies and single studies, thus indicating that two thirds of articles used case studies in some form. Drawing conclusions on future research focus from these findings is informed by Tranfield et al., (2003) who contends that many SLRs have researcher bias, lack rigour and have insufficient empirical evidence to underpin insights that could enable intervention into the practitioners' operational roles. This SLR research finding therefore underpins the increasing emphasis towards using empirical evidence and case studies. This suggests that future research should seek design methods that relate to practitioners and thereby help inform the MISI policy formulation and implementation.

2.7.3.3 MISI Related Research Finding 3: Primary geographical focus of study (where the study took place or was focused)

The geographical spread of the articles was significant. There were eleven articles that had a focus on the BRICS (Brazil, Russia, India, China, and South Africa) countries and only two from OECD (Organisation for Economic Co-operation and Development) countries. There were also some outliers that included Mozambique, Curacao, Ethiopia and Somalia. The balance of articles between developed countries (n=26) and developing countries (n=4), with a smaller number having a global focus, shows that there remains a predominance of research in the more accessible databases of developed countries.

The larger data set of articles from, and of, developed countries indicates a prevalence of research due to more accessible databases of developed countries as well as a larger body of research resource capacity. The finding is that there is an opportunity to close the gap by focusing more research resources on developing countries since that is where many of the greatest SDG challenges are situated (UN, 2018; OECD, 2019). Whilst this is a finding of the SLR, it is intended to address this gap by designing a MISI model that has broad applicability across all infrastructure sector areas and have international applicability.

2.7.3.4 MISI Related Research Finding 4: Primary infrastructure sector (e.g. water, energy, transport, etc.)

The representation across the infrastructure sector showed (in Figure 12) a dominance of water-focused articles (n=9), followed by urban development (n=6) and energy (n=4). The remaining eleven areas had a combined total of one less article (n=18, versus n=19) of the top three areas. In some cases, the article covered more than a single sector, hence the increased total above the 33 articles analysed.

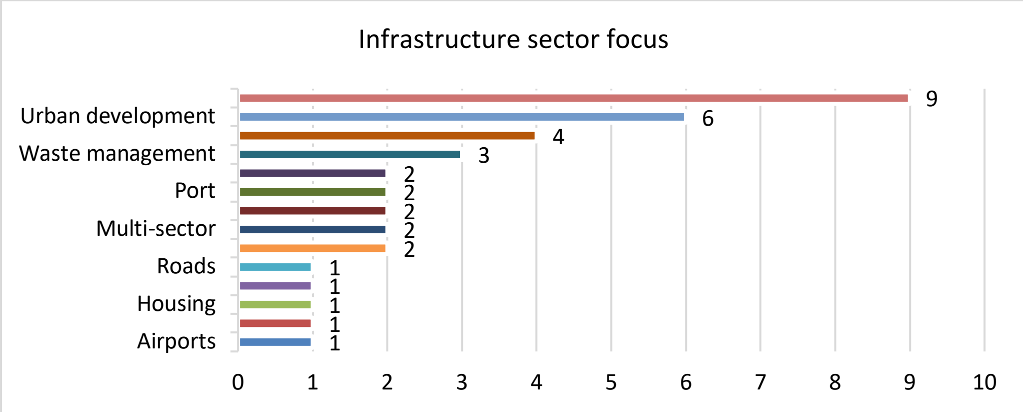


Figure 12: Sectoral focus of subset articles.

The dominance of water-focused, urban development and energy articles suggests key SDG-related IP, such as health (SDG 3 – Good Health and Wellbeing) are under-represented and perhaps, the key enabling IP areas such as roads, housing, sanitation, are also research areas that would benefit from increased focus.

2.7.3.5 MISI Related Research Finding 5: Primary industry (e.g. airports)

The more detailed analysis of each article was carried out to identify their specific subsector focus provided less definitive findings. For example, whilst the prevalence of water sector IP articles illustrated that there were six areas of subcategories used (namely rural water services; transboundary resources; water transfer; river basins and water quality; water supply, solid waste), there was little value gained from further analysis of the other sectors.

The sample set was too narrow to make any significant conclusions from the results but to some extent, the results indicated that the spread of subsector topics in articles is broad, if not deep, across sub-sectors. An opportunity might exist to compare the IP related sub-sector topics with SDG goals and targets, to seek research alignment, for example, analysing SDG targets for SDG 6 (Clean Water and Sanitation) could highlight specific topics related to the targets and their indicators that deserve greater focus. In this case, Target 6.1, 'By 2030, achieve universal and equitable access to safe and affordable drinking water for all', has indicator 6.1.1, measuring the 'Proportion of population using safely managed drinking water services', which could provide a structured way of narrowing the focus for deeper research into specific sub-sector topical areas.

2.7.3.6 MISI Related Research Finding 6: Relevant institutional level (e.g. regional, national, organisational, project)

The analysis of the dataset of articles (see Figure 13) indicates that there is less research conducted at the higher and lower ends of the hierarchy. For example, the top levels from global-national spanned 15 articles, the lower level from sector-project spanned 11 articles whilst the middle three levels from national to industry included 20 articles.

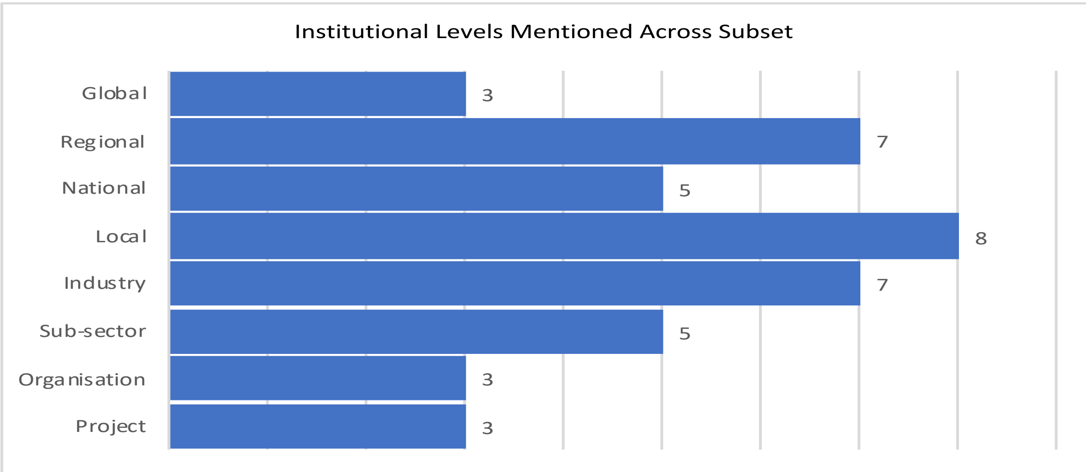


Figure 13: Institutional focus of subset articles

The concentration of articles in the central area is not necessarily surprising but it does highlight the paucity of research at the lower levels that this study seeks to address. Some of the critical observations of this analysis is that this suggests that at the organisational level there is better coverage but that a gap exists at the sector-project level. An existing framework for the analysis across levels is provided by Müller et al. (2019) in their organizational levels in project management (OPM) model (addressed in Chapter 3). In project management terms, this includes the project, programme, and portfolio levels of organisational design and this finding could allow the alignment of the MISI analysis with the Müller-developed theory to help explain the SDG interface and interaction of the OPM elements across the layers within the model.

2.7.3.7 MISI Related Research Finding 7: Sustainable Development Goals mentioned in the articles

The final MISI SLR research findings (#7) was a numeric counting of which specific SDGs (of the 17 goals) were the focus of the articles in the dataset. Unsurprisingly, given the heavy sectorial focus on water in the dataset, SDG 6 on Clean Water and Sanitation, was the most prevalent (n=6). This was followed by SDG 11, Sustainable Cities and Communities, which aligns closely with the search parameters of IP (n=4). Eight articles referred to SDGs in a general reference without a specific focus on individual SDGs and six of the SDGs were specifically mentioned in the articles but with lower occurrence.

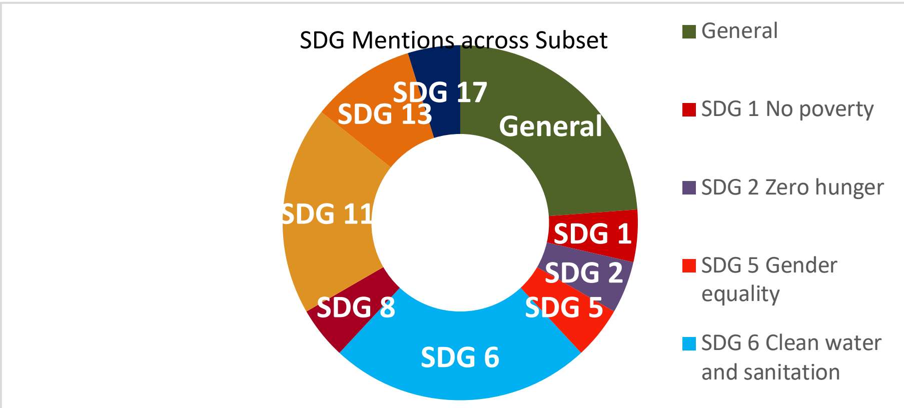


Figure 14: SDG mentions across subset.

The results on this SLR research finding suggests that there is an opportunity to broaden the research across the SDGs that were under-represented, specifically into those SDGs identified as being most affected by the development of infrastructure, or, to deepen the research in areas already covered, such as SDG 6 or 11.

2.8 LEVEL 2 ANALYSIS OF THE 13 TOP MISI ARTICLES BASED ON THEIR KEYWORD OCCURRENCES

Whilst the SLR methodology used in the preceding sections was based on the rules and standards proposed by Liberati et al. (2009), the findings have only provided a high-level indication of how to design this studies research framework. Following the initial sieve of relevant article these were further reduced to the most relevant based on their prevalence of keywords. The articles were then analysed to identify MISI issues and sub-issues that have relevance in guiding the design of the MISI research framework, developed in Chapters 3 and 4. The data in Figure 15 highlights the correlation between the issues and sub-issues and the originating author's reference of where the sub-issues are derived from in the top 13 research articles. This provides the opportunity to use the identified issues to help shape a research 'Variables Framework' (including MISI context and mechanism issues) that can be used for the empirical data gathering in Chapters 5, 6, 8 and 9. A summary of all the relevant extracts from the top 13 articles is included in Appendix 1 and a detailed capture of analysis that indicates emerging MISI propositions is shown at Appendix 2.

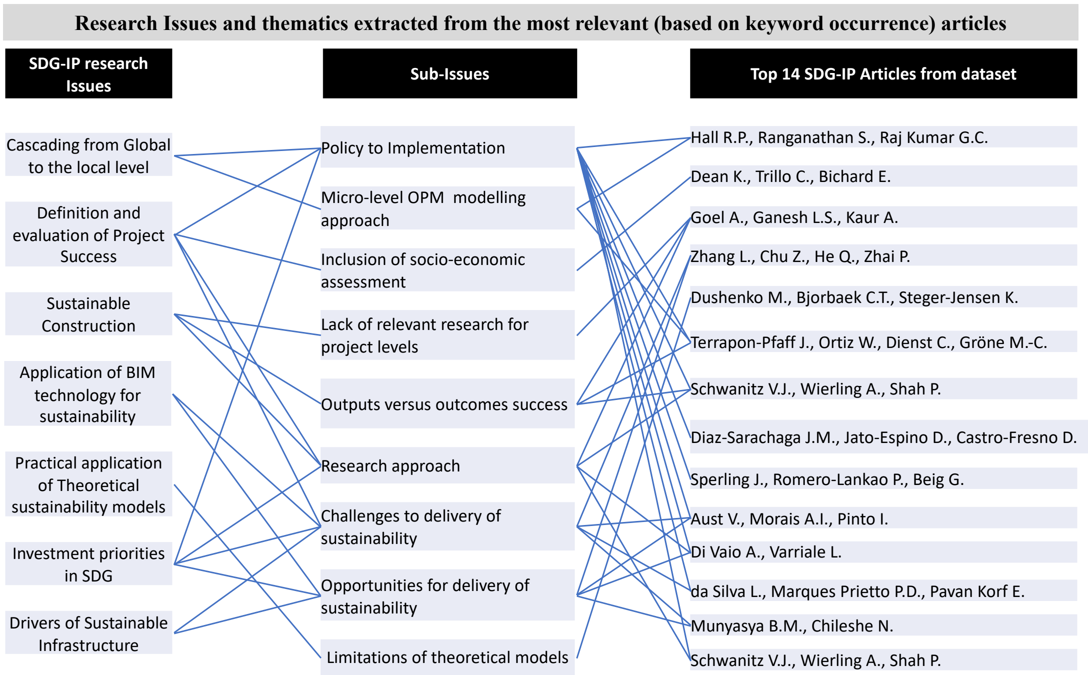


Figure 15: Research issues and sub-issues based on the 13 most relevant articles

Analysis of the nodal framework shown in Figure 15 indicates that there is a balanced spread of the top articles that relate to the identified MISI research issues (shown in the first column) although there are three that dominate: 'definition and evaluation of project success' (n=4); 'sustainable construction' (n=3); and 'investment priorities in SDGs' (n=3). There is clearer differentiation of the most common sub-issues across the research themes: 'policy to implementation' (n=8); 'research approach' (n=4); 'opportunities for delivery of sustainability' (n=4); 'challenges to delivery of sustainability' (n=4); and 'outputs versus outcomes' (n=3).

2.9 SLR FINDINGS FOR DESIGN OF RESEARCH FRAMEWORK

The literature review has sought to explore opportunities for research into the assessment of infrastructure projects through SDG targets. The SLR methodology was adopted to examine a sub-set of relevant journal articles to understand the quantitative data across six MISI thematic areas (see Figure 5) that emerged from the first part of the SLR. Level 2 analysis was then developed to identify some qualitative insights into the type of issues that have been covered within the sample set.

The following sections consolidates the emerging findings from the SLR and have been captured under the headings of the three questions that were identified at the start of this chapter to respond to Research Objectives 1-3.

2.10 (1) HOW EXTENSIVE (BROAD AND DEEP) HAS THE RESEARCH INTO MISI BEEN TO-DATE?

The Level 1 analysis has indicated that there is a growing body of research into MISI, with a marked increase since 2017. The relative coverage of the MISI, against other business and project management research areas is less easy to quantify since SDGs have only been in existence since 2015 and the SDG targets and indicator framework was only fully agreed by the 193 signatory nations in 2016. However, recent SLR studies (Aarseth et al., 2017; Engert et al., 2016) have shown that sustainability in a project context is still a nascent and fragmented research area, but that there is growing awareness of its criticality to business success, and indeed, also to society and environmental success. This reinforces the contention that MISI research is 'nascent' to an even greater degree because there were approximately 300% more sustainability keyword connections than for SDGs.

2.11 (2) WHAT ISSUES AND SUB-ISSUES WERE IDENTIFIED THAT MIGHT INFORM THE MISI STUDY'S PROPOSITIONS?

The level 2 analysis (see Appendix 2) provided useful insights into the issues and sub-issues that emerged from the qualitative analysis of the highest ranked articles in the dataset. This provided an evidence-based MISI 'Variables Framework' (of contextual and mechanism issues) for structuring the MISI research, specifically the emerging propositions. The diagram below (Figure 16) illustrates the emerging issues and context variable in columns 'a' and 'b'. This forms a linkage to supra-themes in column 'c' that are evaluated further in the next chapter.

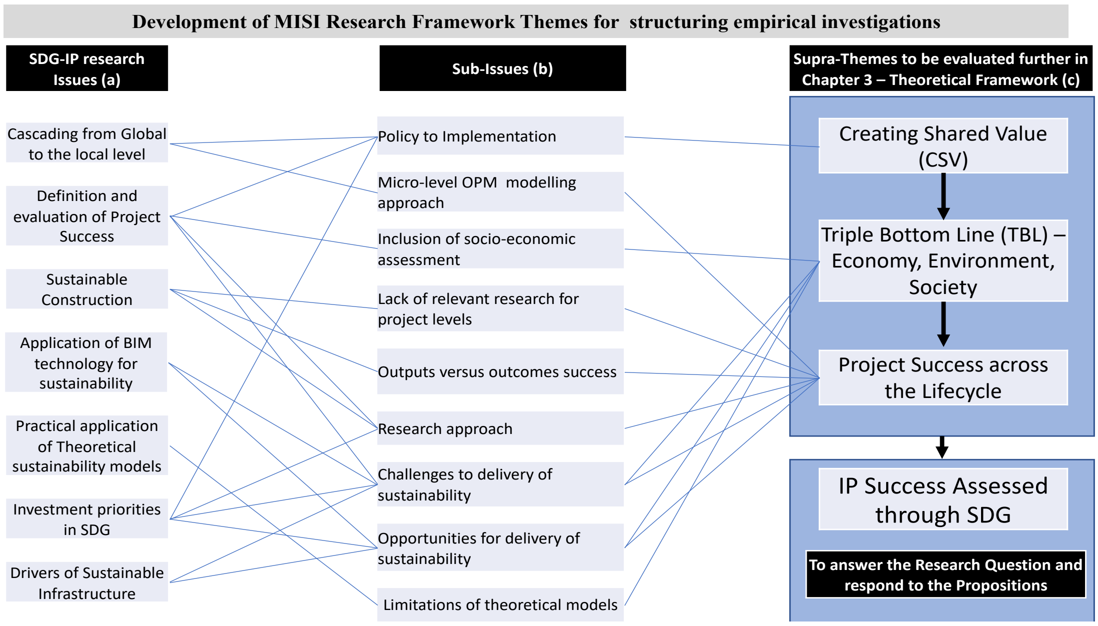


Figure 16: Structure of issues, sub-issues and emerging supra-themes.

Whilst the analysis of the individual articles indicated their specific research focus areas, the overview across all the research articles provided a strategic perspective of linkages between the issues, sub-issues and derived supra-themes. In many cases the studies did not overtly cover these areas, and this could be evidence of a research gap. More helpful for achieving the research's objectives is an emerging research framework that provides a strategic context to refine the empirical data gathering carried out in Chapters 5, 6, 8 and 9. To give an indication of how this might be used, the sections below provide an overview of the main points emerging from five of the seven MISI Research Findings shown in Figure 16 in column 'a'.

2.12 (3) WHAT ARE THE EMERGING MISI PROPOSITIONS?

A recurring theme emanating from analysis of the selected articles is the need to make the research accessible and relevant to the practitioner community of stakeholders, whether policy makers, investors, project managers or others. Indeed, there was a specific thematic area that was identified as MISI Research Issue 4: Practical application of Theoretical sustainability models, which is a theme Tranfield et al., (2003), championed. For this reason, the first two propositions, shown in the table below, seek to establish the sector's MISI viewpoints at an individual and organisational level (Propositions 1 and 2). If these propositions can be confirmed, then a prototype could be developed, informed by their views (individual and organisational) and then tested for a ‘golden thread’ to ensure it is both possible and practical (Proposition 3) and then analysed in a case study context to assess whether the prototype could provide utility (Proposition 4).

The focus on practical application of this research to inform the approach to collect empirical data, is supported by the emerging propositions that this SLR chapter has informed and gives a view of the research ‘direction of travel’. The four derived propositions, as evidenced in Table 39 (In Appendix 2, column ‘e’) and Table 5 (below), drive the subsequent design of the research framework.

Table 5: Derived propositions from the literature review.

SLR Issues	Research derived Propositions
MISI Research Issue 1. *Cascading from Global to the local level (a reality gap from theory to practice)* Hall et al., 2017; Terrapon-Pfaff et al., 2018.	• The literature review highlighted that a significant challenge is how to operationalise the measurement of SDGs. • There was a consistent view that it is considered important, but there was a gap in knowledge as to how to do so. • The identified gap from a number of the papers reviewed suggests that there would be benefit in assessing engineers’ perspectives on whether they have experience of applying MISI successfully on their projects. • The access to engineers, and other stakeholders such as designers, architects and investors, at the project level, would also provide useful insights as to the strengths and weaknesses of MISI. • Also, the SLR highlighted the gap in evidence-based research from sector experts such as engineers (to give the individual engineer’s view at the coalface) and CEOs (at the organisational level). • The SLR highlighted the theoretical importance of this work, but it is not underpinned by evidence. This explicitly seeks acknowledgement that the global SDG goals do have relevance at organisational and project levels, but implicitly seeks to understand the reasons why the current approach is sub optimal and what they believe are ways of improving practical application. • The papers analysed highlighted that there are no consistent or evidence-based methods for measuring global goals at project level. **Derived Proposition**: (for ‘proposition’ or ‘hypothesis’ choice, see section below this table) **Proposition 1: Individual engineers are ‘supportive but frustrated’ in methods to measure global SDG goals at project level.**
MISI Research Issue 2. *Definition and evaluation of Project Success* Dean et al., 2017; Schwanitz et al., 2017; and Diaz-Sarachanga et al., 2016; da Silva et al., 2019.	• The literature suggests that organisations do not have sufficient clarity on the definition of project success and often confuse outputs and outcomes when defining benefits. • There is evidence that there is insufficient value placed by organisations in the longer-term and wider criteria across environmental and societal factors to balance their existing bias to economic and commercial drivers. This needs to be tested with CEOs and leaders of sustainability in organisations. • There is a shortage of research into how organisations balance their ‘strong rhetoric’ for SDG measurement, with practical application of workable models.

	Derived Proposition: **Proposition 2: Organisations' leaders champion SDG measurement without having evidence-based methods to verify claimed impact at portfolio and project levels.**
MISI Research Issue 3. *Sustainable Construction* Goel et al., 2018; Munyasya and Chileshe, 2018.	• Is there a 'golden thread' that proves a linkage from the global SDGs, through organisational levels, down to local project level? • What research across the engineering and infrastructure sector that has focused on measurement of sustainability success on projects can be used for assessment of MISI impact? • What existing tools and processes (e.g. LEED, Envision, CEEQUAL) could be utilised for the assessment of MISI impact? **Derived Proposition**: **Proposition 3: Current sustainability measurement at organisational and project levels can be used to demonstrate a 'golden thread' from 'global' SDG to 'local' portfolio and project levels.**
MISI Research Issue 4. *Practical application of Theoretical sustainability models* Tranfield et al., 2003; Dushenko et al., 2018.	• The evidence from the literature highlights the inconsistent use of a Theory of Change as well as inconsistent use of a more balanced investment decisions across the Triple Bottom Line (TBL). • There is a shortage of practical models that can apply MISI successfully. • The gap identified in the literature indicates the opportunity for further research on strong theoretical or concept models that have relevance for the business and project management communities for the identification and measurement of benefits. • Based on the empirical findings from answering Propositions 1 and 2, there is perceived value in development of a theory-led prototype model that can have practical value in unlocking the MISI challenges, such as being aligned to existing business case and benefits realisation models. • Theory of Change research leaders and practitioners have developed a set of quality control standards for assessing the ToC (Connell and Kubisch, 1998, p.3): Plausibility; Feasibility and Testability (discussed in Sect 3.5.2). **Derived Proposition**: **Proposition 4: A MISI prototype can provide a plausible, testable and achievable logic chain for defining project and portfolio SDG impacts.**
MISI Research Issue 5. *Investment priorities in SDG* Aust et al., 2020.	• What are the MISI contextual issues (political, cultural, environmental and social) that might affect the investment decisions of future infrastructure projects? • What are the likely outcomes of employing a well-defined theoretical MISI model to inform investment decisions? • What investment criteria might inform decisions in sustainable infrastructure and how might the existing frameworks be utilised in future? **Consideration for future research beyond this thesis**: **What are the MISI recommendations from this study that can inform a future research framework** to inform improved infrastructure investment decisions?

2.12.1 Use of Propositions for Research Framework

Further structuring of the research investigation raises the question of selecting either hypotheses or propositions to guide the research. This study has used accepted wisdom (Merriam, et al., 2016) that hypotheses are primarily for quantitative analysis. Propositions can be described as a tentative and conjectural relationship between constructs that is stated in a declarative form (Merriam, et al., 2016). Propositions are generally derived based on logic (deduction) or empirical observations (induction). In this study they are derived deductively from the literature review. Merriam et al., (2016) suggest that propositions cannot be tested directly because they are derived from associations between abstract constructs. Instead, they are tested indirectly by examining the relationship between corresponding measures (variables) of those constructs. The identified variables are derived initially from the Literature Review's findings, then iteratively developed from each stage of the investigation, starting with the survey findings (Chapter 5), that informs the interviews (Chapter 6), that further uses its 'snowball' findings to inform the development of the prototype (Chapter 7). The variables for testing the propositions in the final prototype testing stage, are informed from the previous research. All variables are placed within the theoretical construct of the Realist Evaluation's Context-Mechanism-Outcome model that is introduced in Chapter 3.

2.13 SLR SUMMARY AND IMPLICATIONS

In the context of climate change as an existential threat to the human race, alongside the COVID-19-exacerbated threats of growing social and economic inequalities, rising social tensions, and mass migration (IPCC, 2020; UN, 2020), the international community has responded to the grand challenge of sustainable development with the '2030 Agenda for Sustainable Development', culminating in 17 Sustainable Development Goals, linked to 169 targets and 232 (unique) indicators. The IPCC has identified that "directing finance towards investment in infrastructure for mitigation and adaptation" is key to meeting SDG targets (2018) and the estimated USD $94 trillion infrastructure investment that is required globally between 2018 and 2040 (Global Infrastructure Hub, 2019), represents a significant opportunity to stimulate economic prosperity, reduce poverty and raise standards in living, health, education and gender equality. This is relevant for the project management community, a critical profession in the delivery of infrastructure through projects across all sectors, and thus in development.

As a result of the problem described above, this literature review has assessed the opportunities for research into the assessment of IP through SDG targets, distilled through 3 sub-research questions that were derived from the first three of the 8 Research Objectives[6]: (1) How extensive (broad and deep) has the research into MISI been to-date? (2) What issues and sub-issues were identified that might inform the MISI study's thematic framework to support the empirical data gathering in Chapters 5, 6, 8 and 9? (3) Post this doctoral MISI research, how could such a framework be used to provide guidance to a wider range of stakeholders? Question 1 was answered through a Level 1 analysis of an SLR, which identified seven MISI research findings. Questions 2 and 3 were answered using the Level 2 analysis of the 13 top articles that identified emerging MISI issues, sub-issues and supra-issues.

The SLR research findings identified the recurring need to make research accessible and relevant to the practitioner community by pursuing studies that will result in practical applications for theoretical sustainability models. This culminated in the identification of several findings to structure the next stage of the study: the importance of localising assessment; defining project success in light of the SDGs; expanding on sustainable construction research; driving practical assessment solutions and benefits for stakeholders; and prioritising investment into SDG assessment where it is most critical; both thematically in terms of specific SDGs, as well as geographically, with a renewed focus on developing countries where sustainability challenges abound. With a focus on IP, this SLR finds that SDGs are seldom linked to projects (either in delivery or in their outputs and outcomes) and it is suggested that increased knowledge in this area may improve both IP investment decisions and performance against SDGs.

This has provided an evidence-based framework of contextual issues and propositions for structuring the MISI research and empirical data gathering. In regard to the meaning for the research approach, it was concluded that, in order to develop an

[6] Research Objective (RO)1: To understand the existing knowledge (in theory and practice) on how organisations and projects measure infrastructure projects' SDG Impact. RO2: To understand the context (the 'variables') of the current use of mechanisms to measure infrastructure projects' SDG Impact); RO3: To assess the current MISI mechanisms.

integrated framework to link global level SDGs with project level features and outputs, a number of propositions were needed to underpin the overall research question. This framework was used to answer the Research Objectives, through appropriate empirical studies, such as through a large-scale survey of practitioners engaged on IP delivery (Chapter 5) as well as through case study research (Chapter 9) on portfolio and projects that need to be linked to the achievement of SDG outcomes.

2.13.1 Derived Research Propositions

As mentioned earlier, Merriam et al., (2016) suggest that propositions cannot be tested directly because they are derived from associations between abstract constructs. Instead, they are tested indirectly by examining the relationship between corresponding measures (variables) of those constructs. These variables are derived from the next chapter's investigation of the theoretical framework. The five primary conclusions and four propositions, that were derived from the SLR, were:

- **There is a MISI research gap**. SDGs are seldom linked to projects (either in delivery or in their outputs and outcomes). Increased knowledge in this area may improve both IP investment decisions and performance against SDGs.
- **The research gap includes the lack of empirical evidence that engineers do not have appropriate tools and processes to measure SDG impacts at project level**. The SLR highlighted shortcomings at two main levels: (1) that the overall quantity of material on SDGs measurement at local project level was low, partly explained by the comparatively recent introduction of SDGs to the international lexicon (agreed in 2015 with a measurement framework not agreed until 2017), but also due to the suspected difficulty of cascading the global measurement to project level; (2) the inclusion of frameworks in the SLR papers highlighted that they were conceptual in nature and had reduced application in practice. In addition to these two reasons, the researcher's own personal experience and interface with leading members of the Institution of Civil Engineers (ICE), highlighted a knowledge gap on the availability of suitable tools and processes. This resulted in the author being commissioned by the ICE (co-sponsoring his doctoral research) to specifically review what tools were available and whether these were sufficient. This provided the primary official empirical paper that input to the ICE's 200th anniversary conference on SDGs in London in October 2018, attended by over

2000 delegates from 120 countries. The structure of the survey questions (shown in Chapter 5) that informed the SDG Conference paper specifically addressed this gap in knowledge and provided empirical evidence that over 2/3 of the engineering community surveyed, confirmed that the tools and processes were inadequate to measure SDG impacts successfully at project level.

- **A framework for this MISI research has emerged**. The findings from the SLR have provided an evidence-based logic to the formulation of the research design in Chapter 4. The framework has also informed the selection of which empirical data research is required and starts to formulate a strategy to achieve the MISI research's objectives.
- **More empirical evidence is required for development of practical MISI approach**. It is shown that further empirical evidence is required in order to develop an integrated framework to link global level SDGs with project level features and outputs. e.g. a large-scale survey of practitioners engaged on IP delivery (Chapter 5) that might include interviews with CEOs to access the organisational perspective (Chapter 6).
- **A MISI prototype, with practical utility, could help address the gap** if it is validated as a value-add approach in terms of time and effort to deploy in construction organisations. Such a framework should then be tested through appropriate case studies (Chapters 8 and 9). This could usefully include investigations at the portfolio, megaproject and project levels, to test whether they can utilise global SDG targets at the local project level.

Based on the research question of *'How can global SDG goals be used to define and measure infrastructure projects' SDG impact at organisational and local project levels?*, the underpinning propositions, derived from the SLR, were:

- **Proposition 1**: Individual engineers are 'supportive but frustrated' in methods to measure global SDG goals at project level.
- **Proposition 2**: Organisations' leaders champion SDG measurement without having evidence-based methods to verify claimed impact at portfolio and project levels.

- **Proposition 3**: Current sustainability measurement at organisational and project levels can be used to demonstrate a ‘golden thread’ from ‘global’ SDG to ‘local’ portfolio and project levels.
- **Proposition 4**: A MISI prototype can provide a plausible, testable and achievable logic chain for defining project and portfolio SDG impacts.

These propositions will be used to inform the research design discussed in Chapter 4. The initial testing of the propositions in the survey (Chapter 6) will provide insights that can inform the design of the interviews (Chapter 7) in order to give a richer description of the phenomenon of interest and deepen the understanding into the research question. At the end of each chapter, a table will illustrate each propositions’ evolving maturity based on analysis against the defined variables.

Chapter 3: Theoretical Framework

3.1 OUTLINE OF THIS CHAPTER

This chapter discusses the theoretical framework by first describing (Section 3.2 – Theoretical Lens) how the Critical Realism perspective of ideological philosophers such as Bhaskar (1978) informed the study's choice of the Realist Evaluation approach, championed by Pawson and Tilley (2004). This introduces the Context-Mechanism-Outcomes model that provides the overarching research framework for the study. The chapter then introduces the four theories that have provided the central core to the thesis. Of these, firstly (Section 3.3) it introduces the project organisational structure developed by Müller, Drouin, and Sankaran (2019a) who proposed a layered model of Organisational Project Management (OPM). This enables the structured evaluation of the concept of SDG, from global to local, at portfolio, mega-project and project levels. The chapter then provides analysis of three further theories adopted for the research, including the Theory of Change (Section 3.4 and 3.5), Triple Bottom Line (Section 3.6) and Creating Shared Value (Section 3.7). The four theories are all, directly or indirectly, embedded in the proposed prototype mechanism (developed in Chapter 7), called the Impact Value Chain (IVC).

3.2 THEORETICAL LENS

Saunders' research onion ring (Saunders et al., 2009), originally developed in 2007 (shown in Chapter 4 at Figure 31), provides a recognised framework to explain this study's theoretical and methodological position. This chapter deals primarily with Level 1, the philosophical stance, and the following chapter deals with the other five layers: approaches; strategies; choices; time horizon; and the techniques and procedures.

As regards the philosophical stance, the study recognises the separate characteristics of the key ontological and epistemological assumptions and positions, across a spectrum of positivism, realism and interpretivism, as described by Saunders (2009). However, these are boxes that do not always neatly fit with practical considerations of the theoretical frameworks. Some believe that this leads to a flawed dichotomy (Pawson and Tilley 1997; Vincent and O'Mahoney, 2018) between objectivist (positivist, deductive, and empiricist) approaches, that have typically been used for quantitative empirical methods, and subjectivist (social constructionist, inductive, and interpretive) approaches, that are typically used with qualitative methods. This is not consistent with the proposed SDG phenomenon of study since no single approach covers the issues adequately. To overcome this identified restriction, the approach has sought a 'balanced dualism' (objectivism and subjectivism) (Vincent and O'Mahoney, 2018). This is helped by understanding the difference between ontology (what is real) and epistemology (what we know). Consistent with the Critical Realist school of thinking, this study accepts the reality of an objective (intransitive) world that has properties that can be studied using scientific means but strongly believes that most knowledge in the MISI area of study is a subjective, discursively bound (transitive) (Saunders et al., 2009) and within a constantly moving social construct. Crucially, for the purposes of this chapter, the methodological focus provides a rationale with which to build the overall research, as a link between the epistemological knowledge and reality of the ontological position. In doing so, it enables the researcher to build a stronger research framework, and thereby better understand the world of the SDG phenomenon. This does raise a quandary of the participants of the research, who themselves are often unaware of the structures and organisations in which they exist. As a result of these tensions, this study has chosen a philosophical position aligned with the Critical Realism (CR) perspective of philosophers such as Bhaskar (2013), since CR applies the earlier discussed 'balanced dualism' of objectivism and subjectivism. In subsequent sections, this will be described further as to how CR informed the choice of the Realist Evaluation (RE) approach, primarily because of its practical utility and its widespread use in social science research into the impacts of programmes (Linsley et al. 2015). It also provides a way to develop theory-led investigations, as described in the next chapter, which is what this research seeks to do on SDG measurement.

3.2.1 Critical Realist Ontology

The origin of critical realism, as a philosophy of science, is attributed to a series of books by Roy Bhaskar (1975, 1979, 1994). He argues that the universe, including the social world, is a 'stratified and open system of emergent entities' (Bhaskar and Lawson, 1998). These entities, shown by the three levels in Figure 17, are "things which 'make a difference' in their own right, rather than as mere sums of their parts"

(O'Mahoney and Vincent, 2014). Unlike ‘variables’ which only record or register (quantifiable) changes and do not offer causal explanations (Sayer, 1992), entities have causal power and properties which can generate real effects (Easton, 2010; Mingers et al., 2013). As shown in Figure 17, these entities can exist in two dimensions, either intransitive or transitive. For this study, they can be interpreted as potentially being physical, social, human, or conceptual entities (Easton, 2010). These provide the basic building blocks for the proposed MISI theoretical understanding and development of a new prototype, that through theory and observation, develop knowledge and insight about the MISI mechanism, through which action causes an outcome, dependent on the context (as shown in Figure 17). The multi-level nature of entities implies that entities can construct reality at different levels in both transitive and intransitive dimensions. Bhaskar (1978) illustrates this ontological position via his assumption of a stratified model of three interrelated domains of reality: the empirical, the actual and the real. As reality is a complex web of mechanisms and events reacting intra and inter levels, that is ‘multiply determined’ (Bhaskar 1975), multiple ‘variables’ must be teased out from detailed investigation of the context. It follows that the critical realist approach to the MISI research is that it seeks to find causation and impact at deeper levels than previously known.

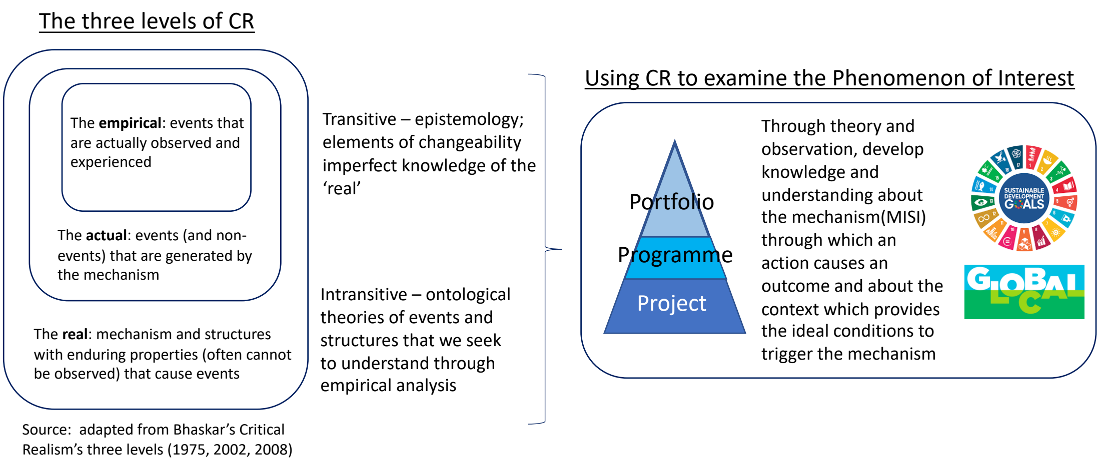


Figure 17. The Critical Realism theory of real-actual-empirical adapted from Zachariadis et al. (2013) linking to the Phenomenon of Interest of the study.

The three domains that Bhaskar (1978) describes (shown above) as the ‘empirical’, the ‘actual’ and the ‘real’, provide an insight into the qualitative study approach. The empirical is typically what is perceived to be ‘fact’ such as what we observe and hear. This is distinct from the ‘actual’ event that happens at a specific time and space that may be different to what we have perceived to be the case. This is further deepened into the 'real' dimension that is constituted of the mechanisms and structures which generate and explain events. Through understanding these stratified layers, the researcher is better able to accept that perceived reality is not the actual reality. This can shape the methodology so that an understanding is explicit that the observer can only attribute meaning to what empirical evidence is provided and through this interpretation, attempt to plausibly define a deeper meaning that more closely aligns to the 'real'. Bhaskar (1975), suggests that multiple causes must be evolved from detailed explorations of the context. The understanding of the context in which the mechanism operates provides a better causal model to understand the outcomes in the actual and potentially, provide insights into the 'real' world/s. As a result, the critical realist researcher seeks a deeper level of understanding beyond direct observation, that affect the outcomes. Therefore, the task of the study and the approach taken by the researcher, was to identify a causally meaningful, testable, and reliable explanation for observed MISI events, or patterns of events, via the selection of an approach that recognised the three domains and also provided a way of distilling the powers, entities, mechanisms and relations which created them. This led to the selection of the C-M-O model discussed below.

3.2.2 Realist Evaluation's Context–Mechanism–Outcome configuration

The Realist Evaluation's Context–Mechanism–Outcome (C–M–O) configuration (Pawson and Tilley, 1997) is widely used across clinical research (Pawson et al., 2005) and increasingly also across the social sciences (Linsley et al., 2015). Pawson and Tilley specifically recommend the C–M–O strategy so that 'programme theories can be tested for the purposes of refining them' (2005, p. 2). In this regard, the investigation is not about what works but asks instead, 'what works for whom in what circumstances and in what respects, how?' (2005, p. 2). Therefore, this approach gives a multi-layered methodological framework for analysing engineers' perception of the context of SDG measurement as well as its potential outcome on redefining investment decisions to achieve broader SDG impacts. For the purposes of the thesis, the definitions of C–M–O are:

- **Context**: The conditions in a context of action encompass 'material resources and social structures, including the conventions, rules and systems of meaning in terms of which reasons are formulated' (Sayer 1992, p. 112; in Easton, 2010).

- **Mechanism**: The underlying entities, processes, or structures which operate in particular contexts to generate outcomes of interest (Astbury and Leeuw, 2010, p. 386).
- **Outcome**: The practical effects produced by causal mechanisms being triggered in a given context (Tilley 2016, p. 145).

The conceptual interpretation of the C-M-O model, from a Realist Evaluation interpretation of the Critical Realist approach, is shown below.

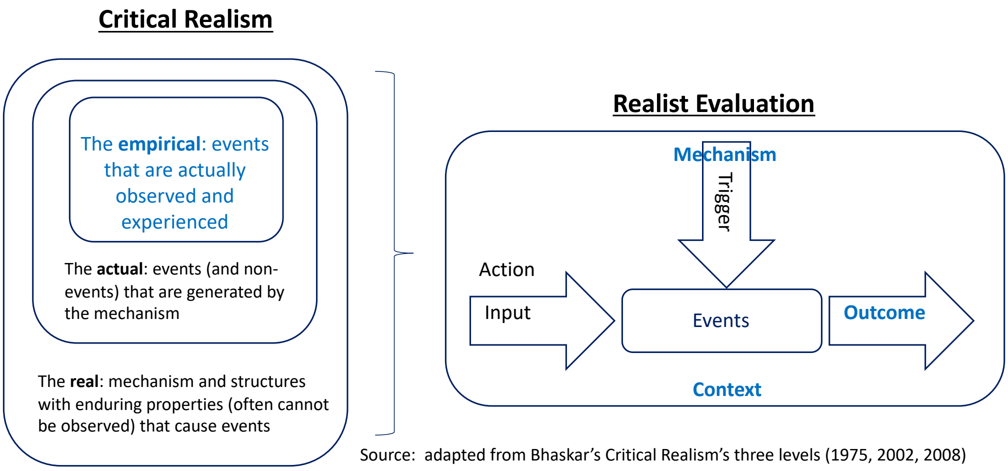


Figure 18. The Realist Evaluation (Context–Mechanism–Outcome (C–M–O)) model mapped to the Critical Realism theory of real-actual-empirical adapted from Zachariadis et al. (2013).

In the engineering research field, the C-M-O configuration is not as widely used as it is in the clinical field, and therefore the choice of this approach has been compared with other relevant applications on engineering projects and specifically, what design features can be drawn from them for the MISI study, as detailed in Table 6.

Table 6: Examples of the use of Critical Realism and Realist Evaluation C–M–O configuration on engineering projects that informs similar use for MISI research.

#	C–M–O Configuration Reference	How does this inform this study's MISI analysis?
1	**Terminology**. Pawson and Tilley's Realistic Evaluation (Pawson and Tilley, 1997) is widely held as the originators of the Realist Evaluation CMO configuration.	Through understanding the origins of the C–M–O approach and its terminology, research into engineering projects can build on established protocols and use their approach to widen our understanding of its employability outside the clinical and educational sectors, where they are most frequently used.
2	**Projects application**. Pawson and Tilley's Realistic Evaluation (Pawson and Tilley, 1997)	Pawson and Tilley suggest that the value of the C–M–O strategy is that it enables the researcher to better analyse the nature of programmes and projects and, more importantly, how they work. Thus, the core element of the realist approach is to provide a new perspective on how intervention using a mechanism brings about outcomes that represent change. Engineering-based research can thus adopt Pawson and Tilley's approach to

		better understand and explore the mechanism of change in order to evaluate a project or programme.
3	**Engineering application**. Tilley (2016) developed the C–M–O model to assess how it can be used by engineers to improve their decision making for policy and project decisions.	As a proponent of realism, Tilley argues for a pragmatic approach in engineering to be adopted for its evaluations. The research adapts the C–M–O model to the EMMIEI approach that includes Effects, Mechanism, Moderator (or context), Implementation and Economic Impact. Importantly, the differences between engineering physical worlds and the social world are recognised, but it is suggested that both benefit from a pragmatic research strategy. This is helpful for the measurement of SDGs because it gives confidence of relevance to the engineering domain of using the C–M–O configuration.
4	**Engineering application**. Horrocks and Budd (2015) used the C–M–O structure to evaluate a European e-services systems engineering project to establish the outcomes and understand the why, for whom, and how?	The project evaluation of ‘e-government for You’ used the theory-driven evaluation approach based on the C–M–O model to enhance the focus and granularity for their study. This supports the usage of the C–M–O model for SDG measurement because it allows for the mixed-method approach and structures the analysis framework in a readily understood causal chain.
5	**Construction project application**. Peters et al. (2013) examined Critical Realism evaluation models to study business networks. They used a UK construction project to explore the managerial phenomenon, specifically the practice of novation in temporary organisational networks.	The origins of the C–M–O model are from the Critical Realism traditions, and therefore, the Peters et al. (2013) article provides a useful insight into the approach that a strongly theoretical lens can use when applied to the ground level of a local construction project. This helps shape the SDG approach by giving confidence that the ‘realistic learning’ from the Peters study can be replicated for SDGs.
6	**Construction project application**. Poirier et al. (2016) evaluated the use of a Critical Realism lens to assess the delivery of building projects in the architecture, engineering and construction (AEC) sector. They evaluated how collaboration can improve performance and value across five core entities, namely process, structures, agents, artefacts and context.	There are strong parallels of the study into the AEC’s value derived from collaboration in project delivery. The relevance to the C–M–O approach is that they both derive from the critical realism tradition and seek to understand causal patterns and assess what are the outcomes of employing a specific mechanism within a given context. In particular, the study highlights how the learnings can be structured in a way that is most readily understood by practitioners in an area of great complexity.
7	**Multi-sector application**. Although Bergeron and Gaboury (2020) come from a clinical care perspective, their recent study highlights some of the challenges of using the C–M–O framework that has relevance to all disciplines and sectors that use its causal framework. Further challenges were also identified in the article described below, by Crosthwaite.	There are a number of methodological challenges that are identified and should be noted by engineering researchers using this approach. Solutions to the analytic difficulties are shared that can help the identification of patterns and assist the researcher to maintain transparency in the analytical process, thus strengthening the ability to make generalisations.
8	**Education application**. Crosthwaite et al. (2012) used the C–M–O approach to understand the educational impacts of the	While not focused on an engineering project, this article highlights the use of the model in the education sector to evaluate the causal impact based on the identification of specific issues within the C–M–O framework. In regard to the SDG approach, there is value in combining the

	‘Engineers without Borders’ in Australia and New Zealand.	qualitative and quantitative approaches to improve the understand the observed outcomes.
9	**Health system application**. Greenhalgh et al. (2009) used the C–M–O method to evaluate a health system. This wide-ranging analysis of a systems transformation environment sought to understand the reasons for how and why the outcomes were achieved.	The broad nature of evaluating organisational systemic transformation has similarities of complexity with research into the measurement of SDG impacts at project and organisational level. The simpler C–M–O approach offers a means to help explain causal effects more simply, and this has benefits for both research and practitioners.
10	**Projects application**. Berge (2017) used a realist evaluation approach on a Norwegian telecare project. While the study has a clinical orientation, its project approach is instructive.	Realist evaluation is used to scrutinize what it is about the telecare system that works for whom, why, how, and in which circumstances. The study provides a more nuanced approach.

The analysis provided above in Table 6 confirms that the C-M-O configuration does have relevance in the engineering research field, and therefore it is taken forward as the proposed theoretical research framework, and developed further in the next chapter, where it provides the guidance and structure to apply a mixed methods approach. The next sections provide analysis of the primary theories adopted for the research, including:

- The layered model of Organisational Project Management (OPM) proposed by Müller, Drouin, and Sankaran (2019a) – in Section 3.3.
- Theory of Change – in Section 3.4 and 3.5.
- Triple Bottom Line – in Section 3.6.
- Creating Shared Value – in Section 3.7.

3.3 LAYERED MODEL OF ORGANISATIONAL PROJECT MANAGEMENT (OPM)

This section establishes the organisational boundaries that are central to the research area and also builds on the 7 contextual variables from the SLR in Chapter 2, by extending them to nine contextual variables that provide a ‘lens’ for the research design. Given the challenges of cascading global and national SDG targets to the local level identified in Chapter 2, the research took an organisational-centric perspective to better understand the ‘global-to-local’ context. To remain consistent with the most recent developments in academic literature, the study used the Onion Model proposed by Müller in his book ‘Organizational Project Management’ (Müller, Drouin and

Sankaran, 2019). Their work offers a seven-layered model that provides ‘logical cohesion’ and ‘logical adhesion’ inter and intra layers. It also provided an adaptable framework and a common terminology to distinguish the structural units to be investigated. In this case, the study focused on the three layers of: Business Integration; Organisational Integration; and Project Governance, shown in Figure 19. Within these layers are located the units of study, both contextually and organisationally. This provided a portfolio perspective that could cascade an agreed organisational approach on SDG measurement to its projects and programmes within its portfolio. Finally, the Project Governance layer is highlighted because much of the measurement of SDG impacts is done at this layer and therefore it was important to consider how the SDG measurement approach would be delivered at the project ‘coalface’.

Leveraging the analysis from the systematic literature review, shown in Figure 15 and expanded in Appendix 2, that identified a nodal structure in column ‘b’ and the context variables in column ‘c’, these issues and variables have been applied to the Müller OPM Onion Model (Müller et al., 2019). This provided the link to shape the evolving evidence based MISI research framework, shown below.

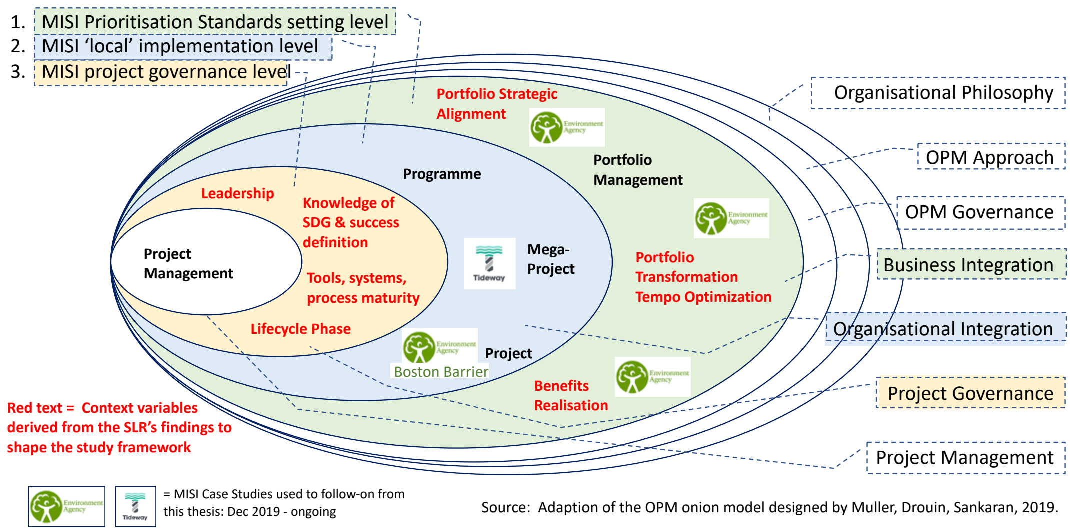


Figure 19: Adaption of the OPM onion model (Müller, Drouin, Sankaran, 2019) showing: three SDG measurement domains: portfolio prioritisation (yellow), local implementation (blue) and project measurement governance (green), mapped to Muller’s seven levels.

There were nine contextual variables identified within the OPM model that were included in the study. Seven of these variables were derived from the SLR’s findings (highlighted in red text in Figure 19) with the additional two issues being: level of organisational complexity (the three levels shown in the Organisational Integration onion ring); and the 'Type of Organisation' that sits within the Organisational Philosophy layer. The MISI relevance of these nine variables, is shown in Table 7 below.

Table 7: Summary of contextual variables across organisational boundaries using the Muller Onion Model (Müller, et al., 2019).

Layer	**Context Variables (9)** **from SLR and OPM**	**Relevance to the research question:** **'How can global SDG goals be used to define and measure infrastructure projects' SDG impact at organisational and local project levels?'**
Organisational Philosophy	Type (complexity) of Organisation (its business nature)	The characteristics of the organisation determines its potential SDG approach. This includes: its presence in the marketplace (local, regional or global); its interaction with its partners, suppliers and customers (do they require SDG measurement, such as in UK on Net Zero 2050 targets); sector – private or public (eg using the updated Green Book (2018) that requires alignment with SDG impacts) and also across infrastructure types such as energy, water, etc. Muller et al (2019) describe this as also including whether the organisation is project based (all work is done in projects), project oriented (almost all work is done in projects), or process oriented (all work is done in production process). Also see Miterev et al., 2017; Soderlund, 2004.
Business Integration	Portfolio Strategic Alignment	The business opportunities are identified, prioritised and selected. The alignment is both internally and with external stakeholders, such as for the Environment Agency, with local communities that could harness the SDG as a common definition of goals.
	Portfolio Transformation Tempo Optimization	The oversight of the portfolio office also provides the function of monitoring the overall transformation tempo of the organisation. If the SDG measurement is excessive, there is liable to be a reduced performance due to 'change overload'.
	Business Case & Benefits Realisation	The management of the portfolio benefits being aligned to SDG impacts provides the link between organisational strategy and delivery success based on business case assumptions. (Killen and Drouin, 2017; Keeys & Huemann, 2017; Marnewick, 2016)
Organisational Integration	The level of the portfolio-programme-project being investigated	Muller et al (2019) consider this layer to be how it addresses the form of organisational integration of project-related work, which has a strong influence on the way project SDG governance is performed. Eg is it a mega-project which imposes other forms of self-governance since they are often temporary self-governing organisations. As such the megaproject typically identified by its scale (over £1Bn), timeline (often over 10 years), complexity and number of sub-projects and suppliers (Flyvbjerg, 2014), often as their own Special Purpose Vehicle and legal entity (Sainati et al., 2017), such as with Thames Tideway project.
Project Governance	Leadership	Leadership is known to be critical to success, both at the project, portfolio and organisational levels. The success of introducing innovative new methods of SDG measurement, which is complicated, requires clarity of direction and allocation of the right authorities to a high performing team. (Davies and Hobday, 2005; Davies et al., 2009)
	Knowledge of SDG and success definition	Knowledge is a critical contextual issue because it enables informed consideration of how to maximise the SDG measurement opportunity. The ability to overlay the new SDG approach needs to be based on a good understanding of both the SDGs and the traditional definition of project success (see links to Benefits Realisation above) (Hwang and Ng, 2013)

	Tools, systems, process maturity	The Muller onion diagram included a strong link between roles, policies, relations and methodology in the project governance layer. The methodology includes the tools, systems and process maturity that are both in existence and need to be adapted if the introduction of CMM-type maturity model for SDG measurement is to be successful. (Sun et al., 2009)
	Lifecycle Phase	The stage of the project impacts the use of the new approach. Eg the use of the Thames Tideway Tunnel megaproject and the Boston Barrier project were both midway through their delivery stage. The case study seeks to assess whether it can be used for both new and 'in-flight' projects. (Martens and Carvalho, 2017; Okland, 2015; Silvius et al., 2012)

3.3.1 Identification and proposed usage of the 9 'Variables Framework' issues

The 9 contextual variables identified in Table 7 above, in future referred to as the 'Variables Framework', have been derived jointly from the SLR's nodal structure of context variables (shown in Figure 15) and the Müller OPM Onion Model (Müller et al., 2019). This informed the evidence based MISI research framework, shown below that will be taken forward as the 'Variables Framework' for investigating the propositions, since it is suggested (Merriam et al., 2016) that propositions cannot be tested directly because they are derived from associations between abstract constructs. Instead, they are tested indirectly by examining the relationship between corresponding measures (variables) of those constructs, by gathering empirical evidence from the surveys and the interviews. They will be iterated through derived learnings at each stage of the investigation to inform the proposition analysis, thereby meeting the research objectives and answering the research question.

3.3.2 The hierarchy/levels between project-organisation to the SDG Global Goals

When considering sustainability and SDG reporting at project level (Mansell, 2020a), there are two core 'project lifecycle' 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 Figure 20 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.

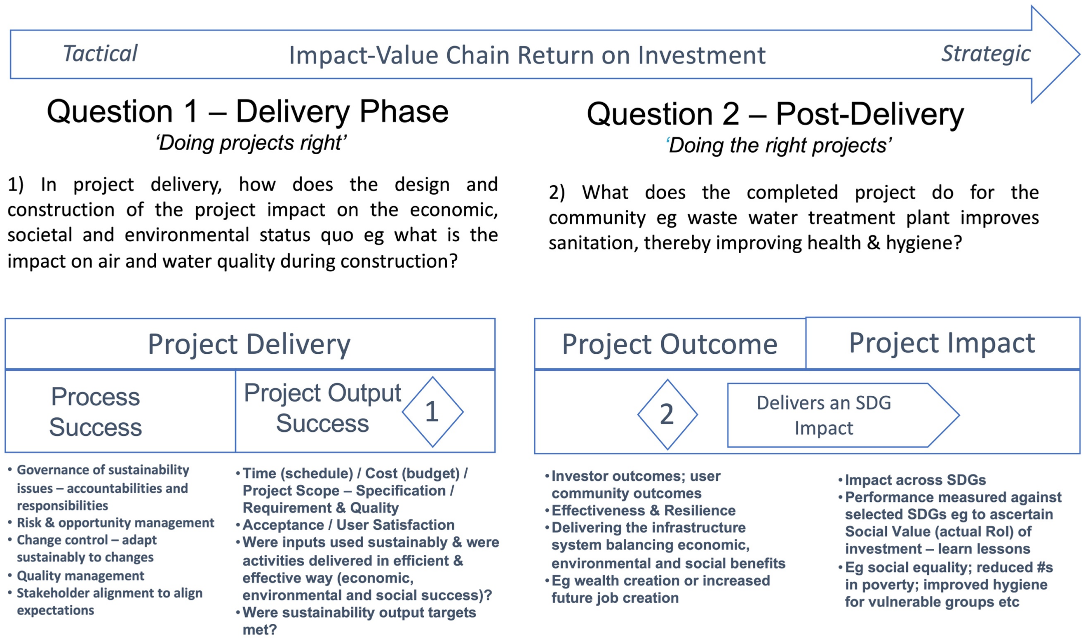


Figure 20: Framework for sustainability and project success reporting depicting the two core sustainable development questions at project level.

A further dimension that aids understanding of SDG impacts on infrastructure projects is the hierarchy, or levels, of SDG reporting as shown in Figure 21.

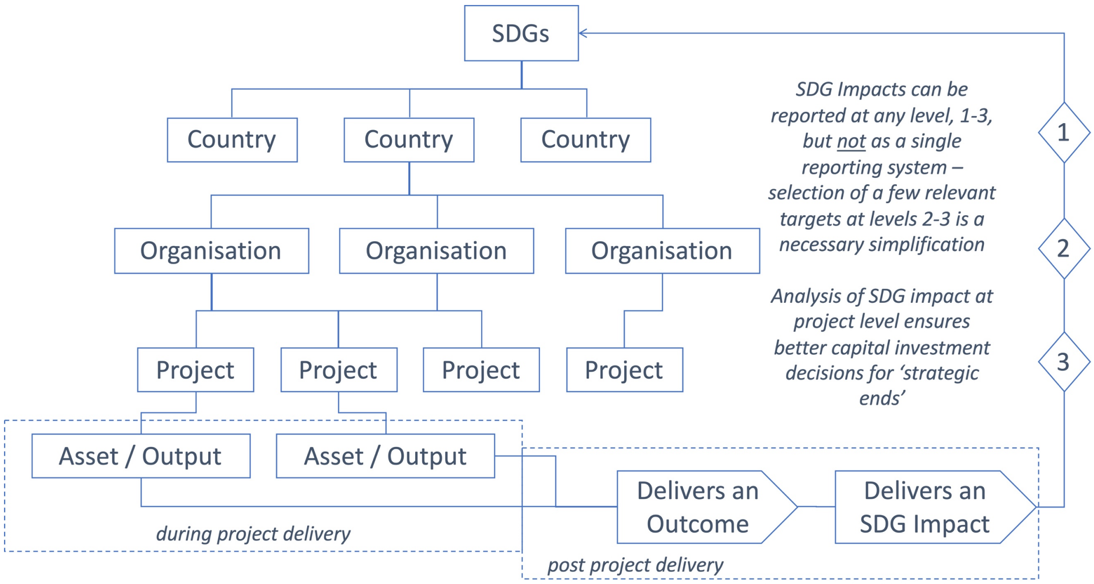


Figure 21: SDG Hierarchy of SDG target reporting using Impact value Chain (IVC) outcomes and impact causal chain[7].

[7] The diagram was designed solely by the author but later used extensively by Buildings Research Establishment to explain how they link project sustainability reporting to SDG impacts. See *The Built Environment and Future Sustainability - The relationship between BREEAM and the Sustainable Development Goals*, P6, Figure (BRE, 2020) accessed at https://files.bregroup.com/breeam/sdg/BREEAM_SDB_A4%20_BRE_115430_0720_web.pdf .

The diagram in Figure 21 highlights 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) (as shown in Figure 20); there are different reporting requirements at each of the levels (depicted by the numbers 1-3 in Figure 21) 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.

3.4 PROJECT SUCCESS THEORETICAL FRAMEWORK: CORE THEORIES OF THE THEORY OF CHANGE AND THE TRIPLE BOTTOM LINE

3.4.1 Theory evolvement and selection

The study provided an opportunity to harness the researcher's cross disciplinary background from his completion of masters-levels research (Strategic Studies at KCL; International Relations at Cambridge University and Major Programmes at University of Oxford). These research opportunities introduced strategic theories that, in separate ways, provided frameworks that all helped define delivery success, both at global, national, organisational and project level. These levels represent the 'global to local' paradigm that the study aimed to explore. The five theoretical areas considered are discussed below.

- **Global-to-national Strategic Theories**. The consideration of political-military strategic decision making was informed by Sun Tzu's 'The Art of War' (540BC) and Clausewitz's 'On War' (1812). Both of these have heavily influenced more recent political-military strategic thinking, especially in the extracted principles that many authors have used to propose modern principles for strategic decision making (Handel, 1986; McNeilly, 2003 and 2012). The relevance of these to the development of 'the Centre of Gravity' and 'Ends, Ways Means' theories are reflected in modern political-military strategic theories, including the Weinberger Doctrine and its successor, the Powell Doctrine. These latter two theories placed high importance on ensuring that the 'ends' were well understood before the 'means' (human, political, financial and other capitals) were committed, and also before the 'ways' (operational tactics) were designed to achieve the 'ends' with the available 'means'.

- **Management Theories**. The plethora of management theories that the twentieth and twenty-first centuries have spawned provides a rich resource to identify relevant theories for helping analyse the measurement of SDG success from global to local levels. There are many dimensions to this issue and one of the clearest frameworks is provided by Peter Drucker (1995, 2020) in 'People and performance: The best of Peter Drucker on management'. Drucker also updates this (2020) in 'The essential Drucker' where the interrelation between management, the individual and society are explained. Drucker's 'Management by Objectives' (1995) provides a useful framework to analyse the definition and measurement of the objectives, which is central to the study on SDG measurement. Drucker's work also influenced the subsequent work by Kaplan and Norton (1996) that introduced the balanced scorecard to help structure and focus the measurement of success criteria for modern businesses, in effect, focusing more on future indicators such as innovation, skills and capability and the leverage of technology, and less on the traditional emphasis on past economic and financial indicators.
- **Programme Theory**. There are many programme theories that are discussed later from academics such as Peter Morris and Andrew Davies. Their work has informed more recent work on mega-projects and other mechanisms to consider and address grand challenges that are often at the global level, as well as managing national and regionally important project management activities. The SDGs straddle the global to local levels and seek to address many of the Grand Challenges associated with the 17 Global Goals, such as Climate Change (SDG 13).
- **Transition Pathways.** Transition theories, such as by Frank Geels (2004, 2007), provide relevant insights for sustainability in project management. Geels applies systems thinking to better understand the multi-dimensional nature of agency models and how they impact socio-technical system changes. The transition pathway, whilst not fully linear, does align with evolution theories discussed below, which leads to the selection of ToC as the primary theory of research.
- **Evaluation Theories**. There have been a number of theories that link the management theories of academic leaders such as Drucker, with local

implementation. The most prominent of these researchers has been Rossi and Weis (1995) who developed the 'New Approach to Evaluation' (1995). This heralded a new theory subsequently titled the 'Theory of Change', discussed in more detail later in this chapter.

Having evaluated relevant theories related to the study topic of MISI, the study narrowed its focus to the Theory of Change (ToC) because it provided three separate, but mutually reinforcing, theoretical selection criteria listed by Merriam (Merriam and Grenier, 2019) in her work on Qualitative Research.

- **Appropriateness.** ToC is widely used across the international development sectors and across levels of organisations from global level (the United Nations and World Bank) down through organisations and directly into the projects that deliver the strategic objectives set at higher levels. This is relevant to the MISI study that seeks to identify and harness a model that can demonstrate a 'golden thread' from global to local levels that has utility for practitioners**.**
- **Ease of application.** The author has used the ToC widely during his work for the UK government on mega-projects as well as international projects on behalf of the United Nations. This has given him first-hand knowledge of the ease of application as well as the value it can bring. Conversely, the researcher also recognises the ToC's shortcomings, which provides a useful insight into how existing theories might be improved.
- **Explanatory power**. The power of the causal logic model is self-evident by the wide usage by global organisations such as the UN and World Bank. One indication of the ToC's explanatory power is evidence that it provides a powerful storyline for inexperienced staff in developing countries who are working on projects and who might otherwise not have the formal project training that includes understanding the benefits theories that define impacts and outcomes. The ToC is a theory that can be 'told as a story' which is visually powerful. This helps the research into MISI since the visual illustration of key concepts is critical to making complex interrelationships more digestible to stakeholders and therefore more helpful to align what success means and how it can be measured. The causal logic model is also embedded in core project management theories and practices, such as benefits management, which is directly linked to MISI research.

3.4.2 Project success criteria and output-outcome success criteria

One of the contextual issues identified in Figure 19 is the need for building knowledge on SDGs and the definition of success. This sub-section examines the study of project success, specifically aligned to the logic chain of the output-outcome pathway. This provides the link to the description of the two core theories that underpin the analytical mechanism that is investigated in the case study.

While project success is a heavily researched field of study within the field of project management (Thiry, 2004; Sward, 2006; Jenner, 2010; Müller and Judgev, 2012; Joslin and Müller, 2016), the quantitative analysis of success criteria and their alignment to outputs or outcomes, is less evident. This becomes more problematic if project success is extended to link to the SDGs because they are by definition, global goals, not designed for the local level. Recent studies (Joslin and Müller, 2016) have shown that forty years of research into project success factors and criteria have indicated that project success is the achievement of a particular combination of objective and subjective measures assessed at the project's end. Other research into project success definition (Thiry, 2004; Jenner, 2010; Bradley, 2010a and 2010b; Lavagnon, 2009) has consistently identified benefits and outcomes as being a critical determinant for the assessment of project success. For example, Michael Thiry (2004) highlights that '*too many critical success factors are related to inputs and management processes and not enough on outcomes*'. This is further supported by those (Davies, 2000; Morris, 2013; Terry Cooke-Davies, 2002, 2007) who identify three levels of success criteria: project management success – was the project done right?; project success – was the right project done?; and consistent project success – were the projects done right, time after time? The latter two levels of success are especially relevant at the portfolio level and provides a valuable approach to linking project success with SDG impacts. In other words, did the chosen project deliver longer term impacts that align with SDGs and can these be aligned with the existing benefits realisation approach?

In order to understand the limitations of defining project success in the narrower method (by time and cost), it is necessary to understand the profession of project management that at its core, is a discipline that focuses on the initiation, delivery and completion that often transitions into operations with the initiation, development and delivery of projects (Morris, 2017; Davies, 2017; Atkinson 1999; Lundin and

Soderholm 1995; Davies and Hobday, 2005). Simply stated, this means that there is the delivery of outputs during the implementation stage, but the most important part, the delivery of outcomes, is achieved post project, and it is these outcomes that indicate where most value from the investment are achieved (Morris, 2017; Davies, 2017). As a result, there is a growing need for the project management sector and profession to focus more on 'ends' rather than just the 'means'. The 'ends-ways-means' model from strategic politico-military research (Lykke, 1982; Sen, 2013) is a helpful way to imagine the high-level success definition as shown below in Figure 22. This also relates to projects creating value, which many have argued (Brady, Davies & Gann, 2005), is the need to deliver integrated solutions, especially when considering the delivery of complex capital goods, such as infrastructure. This is important for the research because it provides a simple model to re-vision how SDG measurement can be applied to existing project success approaches that too often had previously focused on the 'means and ways' instead of the 'ends'.

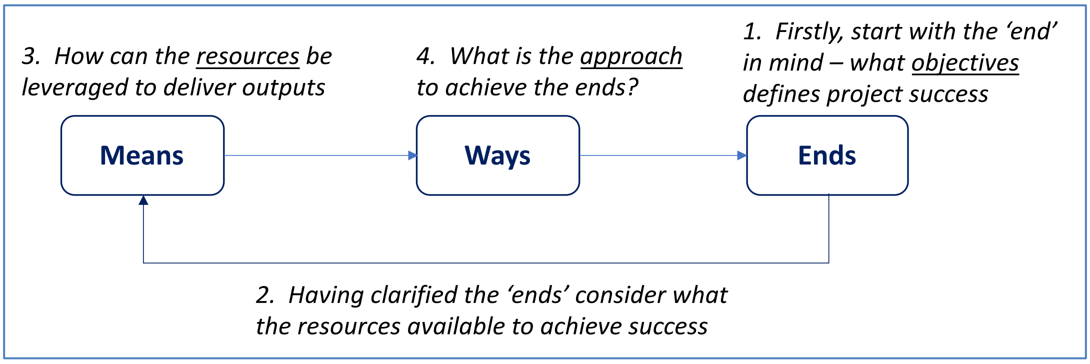


Figure 22: Adaption of the 'Ends-Ways-Means' model (Lykke, 1982; Sen, 2013).

So, given the challenges of defining project success, a new method is needed to align definition of success with the delivery of SDG targets. The Triple Bottom Line and Theory of Change provide a normative and causal theory approach, that combined provide a route map to align with the 'ends-ways-means' model.

3.5 THEORY OF CHANGE

The 'Ends-Ways-Means' model is most commonly identified within the Theory of Change (ToC) (Weiss, 1983; 1995). The ToC is widely used across many academic disciplines, including environmental and organisational psychology, but it has also increasingly been connected to sociology and political science (Rossi, 2018). ToC emerged from the field of programme theory and programme evaluation in the mid-

1990s as a new way of analysing the theories motivating programmes and initiatives working for social and political change. It is focused not just on generating knowledge about whether a programme is effective but also on explaining what methods it uses to be effective. The original work in the 1980s has been developed further by the work of notable methodologists, such as Huey Chen's work on theory-driven evaluations (1990, 1992), Peter Rossi's systematic approach to theory-driven evaluation in social sciences (2018), Michael Patton's focus on integrating the theory with practice (1986, 2014) and Carol Weiss' seminal work that takes a stakeholder-centric perspective (1972, 1983, 1995, 2005) to find more effective ways of evaluating complex community programmes.

Weiss suggests (1995) that complex community programmes had not sufficiently aligned local stakeholders on the change process and what the outcomes will be. She noted that the logic chains are particularly weak in the midsection of the causal chain, without which the longer-term goals are weakened. Weiss uses the term "Theory of Change" to describe the causal links across the inputs–outputs–outcomes pathway. She also focused attention on what users could claim in terms of impacts, separating claims of "attribution" from a wider, less direct, "contribution". Based on her work (1983, 1995), ToC has been applied extensively across international development, public health and human rights and has since become a central theory that underpins the approach to project benefits management (APM, 2018; PMI 2017).

3.5.1 The Causal Link: Outputs-Outcomes-Impacts

For the purposes of this research, the ToC needs to be unpacked further by better understanding the key components of: outputs, outcomes and impact. These are the core terms used to describe long-term, sustainable change in people's lives. However, although the terms are in common use, there are a number of problematic issues with their use. This is critical to MISI because, as discussed earlier, there is evidence that this causal chain has not been established at the sub-national levels. Most organisations recognise the difference between the 'things they do' (activities) and the intended effects/change they want to achieve (impact). But the distinction is not always helpful. In order to achieve desired long-term changes, there may be many steps between an organisation's activities and the desired impact. The MISI research is attempting to find ways to establish a SDG value creation logic.

In the results chain (as shown later Figure 24), inputs are used in order to carry out activities. Activities lead to services or products delivered (outputs). The outputs start to bring about change (outcomes) and eventually this will (hopefully) contribute to the impact. However, there are a number of ToC challenges that impact this research:

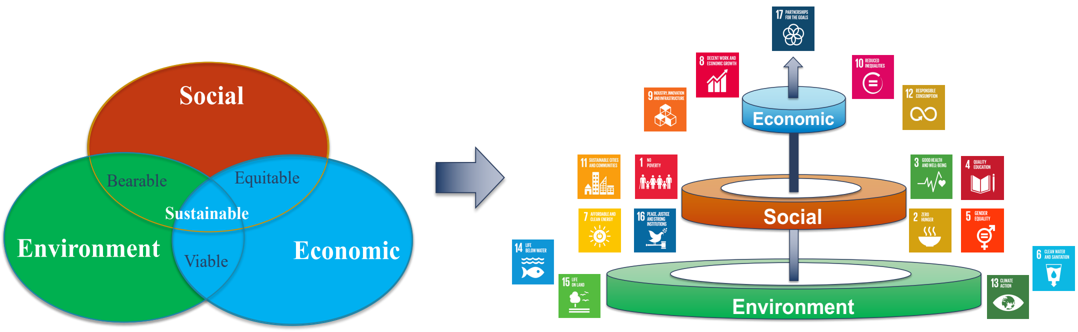
- Many users have difficulty differentiating between activities and outputs, outputs and outcomes, and outcomes and impacts. Thus, the gathering of empirical evidence might have misuse and inconsistent interpretation of these key words.
- The reality that most outcomes are delivered after completion of a project and therefore do not get measured. This reduces likelihood of defining SDG goals accurately since they rarely get measured and also, the lessons of underperformance are unlikely to be captured. This links strongly to project's benefits management knowledge and shares the same difficulties (Edmondson and Nembhard, 2009).
- Logic flow of the map design. There are different opinions on the most logical way to build a map. There are three common approaches: from outputs, to outcomes to impact (left to right); outcomes to impact and outcomes to outputs (inside to outside); and, impact to outcomes to outputs (right to left). This study, as discussed above is firmly in the 'right to left' position since it aligns with the 'ends-ways-means' model.
- Even if a project or programme has a good monitoring and evaluation system it will not make up for poor project or programme design (although it may help to show up these weaknesses). If SDG objectives are unclear or poorly designed from the start, then monitoring and evaluation becomes much more complex and difficult. 'A meaningful plan for monitoring and evaluation can only exist in relation to clearly defined objectives and strategies' (Okali et al., 1994).

3.5.2 Testing Quality of ToC

As the uptake of ToC increased, there was a perceived need to formalise its foundation and provide a framework for further development. This led to research leaders and practitioners developing a set of quality control standards for assessing the ToC (Connell and Kubisch, 1998, p.3). These are: Plausibility; Feasibility and Testability. For this study, they are defined as: (1) Plausible. Does evidence and common sense suggest that the activities, if implemented, will lead to desired outcomes? (2) Achievable/doable. Will the economic, technical, political, institutional, and human resources be available to carry out the initiative? (3) Testable. Is the theory of change specific and complete enough for an evaluator to track its progress in credible and useful ways? A further key ingredient stressed by O'Connor (1995) was the need to better understand the 'context' of both the internal and external environments, in order to predict 'outcomes'. The three ToC quality control criteria and the focus on context and outcomes (as part of the Realist Evaluation mixed method approach) are described more fully in the methodology section.

3.6 TRIPLE BOTTOM LINE

At the project level, the Association of Project Management's Body of Knowledge (APM, 2019) defines 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, 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 (or otherwise noted as TBL or 3BL) of social, environmental (or ecological) and financial aspects.



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

Source: Azote Images for Stockholm Resilience Centre, Stockholm University, 2016. Johan Rockström. Permission to re-use agreed.

Figure 23: The TBL view of economy, environment and social translated into the doughnut view alignment of the United Nations' 17 Sustainable Development Goals by Johan Rockström (2016) (graphic usage agreed).

A contribution to the growing literature on the measurement of infrastructure projects on sustainability is provided by Shen, et al. (2010), who focus on the balance needed between benefits to society whilst protecting the environment and still achieving the economic benefits envisaged in the project business case. The linkage across the three areas in the construction industry is further defined by Kibert (2013), who suggests that the interrelationship between a project's outputs and the society that is impacted is a central component of defining the sustainability success of an infrastructure project. This introduces the concept that project success definition needs to consider success against the triple bottom line (TBL) (Elkington, 1994) of social, environmental (or ecological) and economic (or financial) effects, otherwise noted as the "three pillars" concept of "people, profit and the planet" (Elkington, 1994, 2013, 2018; Griggs et al, 2013). However, the overemphasis on the last of the TBL criteria, namely finance, brings us to the root of the problem of measuring projects' SDG impact (Martens et al., 2016).

The crux of the problem in sustainability reporting lies with the dominance of accounting tools, which has been the pre-eminent business method of reporting for over 500 years, since Luca Paccioli first published his papers on double-entry bookkeeping (Yamey, 1949). This has largely remained unchanged. In other words, there has been a proliferation of mechanisms and economic models to track different elements of the TBL, including ESG (environmental, social and governance) (Elkington, 1994, 2018) that includes the three core areas used in the business investments measurement of ethical and sustainability impacts of a company; Social Return on Investment (SROI) (Emerson et al., 2000; Millar and Hall, 2013), Net Positive (Forum for the Future, 2018; Rainey et al., 2015), Double and Quadruple Bottom Lines (Sawaf and Gabrielle, 2014), a myriad of capital (human, social, manufactured, financial, natural) analysis models, Environmental Full Cost Accounting (Schaltegger and Burritt, 2000), Boston Consulting Group's Total Societal Impact framework, Integrated Reporting (Eccles and Krzus, 2010), Blended and Shared Value (Bonini and Emerson, 2005) and Impact Investment (Bugg-Levine and Emerson, 2011). Recently this has been extended to new frameworks that focus on specific issues such as Sharing and Circular Economies (Preston, 2012), Carbon Productivity (Malhi et al., 2009; Suess, 1980) and Biomimicry (Elkington, 2018). The contention of this research study is that the proliferation of financially driven sustainability measurement theories, tools and concepts causes confusion and often leads to sub-optimal governance because of the short-term focus on profit instead of wider TBL outcomes.

Current analysis suggests that the TBL framework is in need of ‘rethinking’ (Elkington, 2018). Indeed, Elkington’s contention is that his definition has not been implemented according to its true meaning, and he insists that businesses should now monitor and report economic (not just financial), social, and environmental value added—or they will become negatively impacted. Many contend (Hubbard, 2009; Elkington, 1994, 2018; Joyce and Paquin, 2016) that private sector success is still overly influenced by financial perspectives. This is often restrictively linked to share price value and viewed as an inherent weakness of the system that drives short-termism in governance and decision-making (Elkington, 2018). As a result, and relevant to the assessment of how project managers can measure projects’ SDG impacts, there has been a growing demand for knowledge on how sustainability reporting can be broadened.

As a result of the increased knowledge and tempo of the uptake of sustainability language, it has become more mainstream with many academics (Tilt, 2009) and practitioners (Perrini and Tencati, 2006) seeking to further develop the current accounting-centric method towards a broader, or holistic, approach, such as the Balanced Scorecard (Kaplan and Norton, 1996). However, the proliferation of sustainability accounting terminology (sustainability accounting is often referred as social accounting, corporate social reporting corporate social responsibility reporting, social and environmental accounting, and non-financial reporting) also negatively impacts the ability to have a single consistent view, and this contributes to the project world being mired in confusion.

3.7 CREATING SHARED VALUE

The debate on businesses’ responsibility to ‘give back’ to society and the environment have evolved from earlier notions associated with corporate social responsibility (CSR) agenda, and these in turn have been influenced by the notion of creating shared value (CSV), which seeks to change the way in which business creates value for its stakeholders (Porter and Kramer, 2011), i.e., through placing socially aware priorities, such as the SDGs, at the heart of core business’ thinking and strategies. In Porter’s paper (Porter and Kramer, 2011), he states that ‘the concept of shared value can be defined as policies and operating practices that enhance the competitiveness of a company while simultaneously advancing the economic and social conditions in the communities in which it operates'. CSR is clearly a key part of this idea of 'give back to society' and is of importance to investors (Hayward et al., 2013). Hayward goes further by suggesting that the major problem is with businesses, especially the ones that have remained caught in outdated approaches to value creation, that they view too narrowly. In effect, they are seeking shareholder-driven short-term profits before longer-term broader outcome success. Most of the current sustainability efforts have focused on the identification of harms to society in general and the creation of corporate responses to meet those harms. As a result, many sustainability efforts have been largely divorced from the specific business model of each organisation. In reality, sustainability activities have often functioned as 'surplus', 'add-on', 'nice-to-have' actions for the purpose of deflecting stakeholder criticism, conducted regardless of their actual relevance and impact on the business' strategy, capabilities, suppliers or customers. The net effect is to leave core business activities and risks unchanged. Moreover, sustainability cannot be delivered through CSR because it is both inefficient and ineffective (Porter and Kramer, 2011). Porter argues that CSR is inefficient because it can create irrelevant 'add-on' activities that add to the costs of doing business without either adding to the real value created for any of the business' stakeholders or removing real business risks. Additionally, CSR is ineffective because it continues to pit society and business as opposing forces rather than recognising the opportunities dormant in their interdependence (Porter and Kramer, 2011). However, counter to Porter's view of CSV–CSR differentiation, there is an alternative perspective that CSR has rapidly evolved in recent years and closed the CSV-CSR gap. In a recent paper (Albuquerque et al., 2019), they explore how CSR affects systemic risk and impacts the value proposition (Bénabou and Tirole, 2010). This provides useful indicators that suggest CSR is closing a gap with CSV, especially in its social value insights. More importantly for this paper, it illustrates that both CSR and CSV have an important role in linking organisational and project success to SDG impacts.

The CSV business model, first developed by leading business strategist Michael Porter of Harvard Business School (Porter and Kramer, 2011), enables the potential to provide a link from local projects' objectives to global SDGs by rethinking projects' definition of success by demonstrating impact across the TBL (Elkington, 1994), as discussed in the previous section. It can do this because it: (a) recognises the interdependence between society and business; (b) moves society and business away from zero-sum competition to positive-sum competition; (c) enables new ways for the business to create competitive advantage that are more resilient against sustainability risks and mimicry by other firms; and (d) combines traditional CSR and business operations into new, integrated and company-specific, strategies for creating shared value. Since business and society are interdependent, the best outcomes for each will be obtained when businesses develop strategies that integrate social needs with real commercial opportunities and vice versa.

3.8 SYNTHESISING THE INITIAL THEORETICAL MODEL (*IMPACT VALUE CHAIN*) FROM LITERATURE

Based on the literature review from the previous chapter and the theoretical analysis in this chapter, an initial theoretical model has been developed, called the Impact Value Chain (IVC). This section provides the initial description of its design and this will be developed further into a prototype model in Chapter 7, when the triangulation from the empirical evidence is used to strengthen the IVC model that will be tested in Chapters 8 (for a 'Golden Thread') and 9 (with a water utility company).

The initial IVC model is based on four underpinning theoretical models, discussed earlier in this chapter, including: (1) the Theory of Change (Weiss, 1995 and Stein and Valters, 2012), (2) Creating Shared Value (Porter, 1985, 2011), (3) infrastructure systems approach (Hall et al., 2016, 2017; Thacker and Hall, 2018 and Thacker, et al., 2019) and (4) the Triple Bottom Line (Elkington, 1994, 2013, 2018 and 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. The IVC potentially 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.

3.8.1 Concept 1 - The Theory of Change's Impact-Value Chain (IVC)

The overarching IVC model has its roots in the development of the Logical Framework Approach (Baccarini, 1999), also known as the 'LogFrame' or Goal Oriented Project Planning (GOPP) and Objectives Oriented Project Planning (OOPP) methods, in the development sector. Leading authorities such as the World Bank (2004), OECD (2007) and UNDP (2009) have combined with academic research institutions, such as Oxford University's School of Geography and Environment (2014) to develop the temporal logic model to help investors, and wider stakeholders to design, monitor and evaluate development projects (International Fund for Agricultural Development, 2002). These Value Chain methods all stem from the 'Theories of Change' (ToC) (Weiss, 1995; Stein and Valters, 2012) that was discussed earlier. The ToC value chains have a number of principles, which are core to the proposed Infrastructure SDG model: they define long-term goals and then map backward to identify necessary preconditions; they explain the process of change by outlining causal linkages in an initiative, i.e., its shorter-term, intermediate, and longer-term outcomes; and the identified changes are mapped – as the 'outcomes pathway' – showing each outcome in logical relationship to all the others, as well as chronological flow. Finally, the ultimate success of any ToC value chain lies in its ability to demonstrate progress on the achievement of outcomes. Evidence of success confirms the theory and indicates that the initiative is effective. Figure 24 depicts these causal chain relationships.

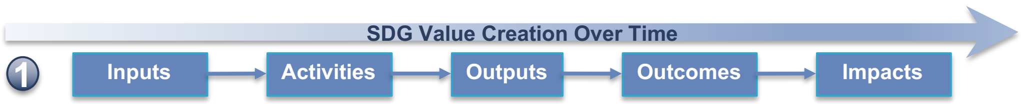


Figure 24: Concept 1 - The Theory of Change's fundamentals for delivering impact (the number '1' in the diagram refers to the Concept number, this is sequentially repeated in the three following Figures).

A core part of this research is understanding the SDG measurement at project level. This stems from an understanding of the project lifecycle and how sustainability reporting is critical to starting the project 'right' with alignment across stakeholders on what impacts define their success and how the Value Chain will be measured. The following supporting definitions are used for the value chain:

- **Theory of change** (Weiss, 1995): '*A basis for planning intervention in a given policy or project arena that helps to identify processes and preconditions whereby actions can best attain their intended consequences*'.
- **Value** (Porter, 1985): '*The worth of a good or service as determined by the customer's preferences and the trade-offs they choose to make given their scarce resources, or the value the marketplaces on an item*'. (Note: these are economic priorities. The wider societal and environmental considerations are

covered within the second dimension of the emerging IVC approach, in the Triple Bottom Line, In para 3.8.4)

- **Value chain** (Porter, 1985; Bloom and Hinrichs, 2011): '*The full range of processes and activities that characterize the lifecycle of a product from production, to manufacturing and processing, to distribution, marketing and retail, and finally to consumption (including waste and disposal across all stages)*'.
- **Impact** (World Bank, 2004): Adapted to: a positive or negative contribution to one or more SDG targets across the TBL of environmental, economic, or social thematic areas.
- **Outcome** (APM, 2012): Adapted to: a change in the extent or condition of the stocks of capital (namely natural, produced, social and human) from the use of an output, due to value-chain activities that deliver SDG impacts.
- **Output** (APM, 2012): '*The tangible or intangible product typically delivered by a project*'.
- **Activity** (APM, 2012): **'***A task, job, operation or process consuming time and other resources in a project to produce specific outputs*'.
- **Input** (APM, 2012): Adapted to: All those items required to undertake work utilising the stocks of capital including financial, natural, produced, social and human resources.

APM references are used above instead of academic references since the majority of academics refer to PMI and APM definitions because they are the terms used most commonly by practitioners. The definitions above are complementary to the definitions in the 'Key Definitions' on pages xv to xvi.

3.8.2 Concept 2 - Delivery of Projects within an Organisational Structure

Infrastructure project management in the built environment is a discipline that focuses on phased delivery, within the parameters of time, cost and scope (and quality), to deliver a defined output, or if a programme, an outcome (APM, 2012). Project management has a well-recognised development process, referred to as the project life cycle (Morris, 2013), which is typically based on a number of iterative and normative stages, such as: plan, design, deliver, operate/maintain, and decommission.

Therefore, understanding the sustainability reporting requirements within the project lifecycle enables the right stakeholders to be engaged at the right time to design the right approach to the definition, measurement, monitoring and reporting of sustainability outputs and outcomes, as shown in Figure 25 below.

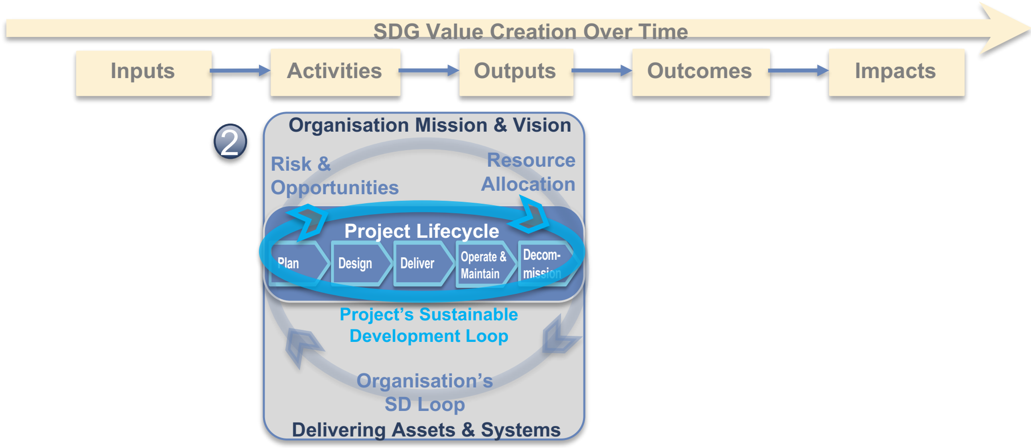


Figure 25: Concept 2 - Delivery of projects within an organisational structure; both with sustainability reporting loops embedded.

The project context is important, especially in its relationship with stakeholders, such as clients, designers, and contractors, because alignment of what success means to different stakeholders is a critical success factor in itself. However, these relationships indicate that the project sits at both inter and intra organisational boundaries, where each organisation has its own sustainability reporting requirements as part of an annual reporting cycle. This is highlighted in Figure 25, showing the proliferation of sustainability reporting instruments; currently in excess of 400, including 170 government and stock exchange / financial market regulations, 129 Codes of Conduct or Guidance, 8 Standards, as well as a myriad of other industry frameworks (KPMG, 2017).

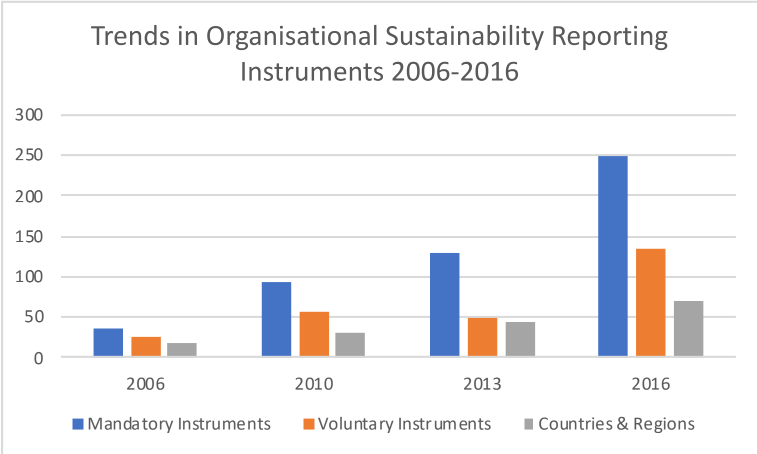


Figure 26: Global Sustainability Reporting. Source data from GRI (2016).

3.8.3 Concept 3 – Infrastructure investments as 'system of systems'.

The layered description of the proposed conceptual model, IVC, is iterated below in Figure 27 , with a third concept that relates to infrastructure projects that are based on a 'system-of-systems' approach (Hall et al., 2016; Thacker and Hall, 2018).

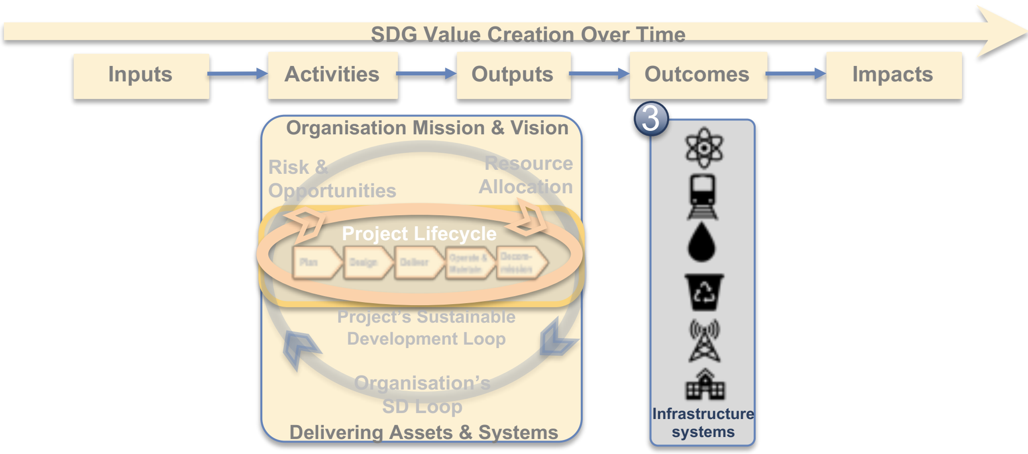


Figure 27: Concept 3 – Infrastructure investments as a 'system of systems' – Source: The Future of National Infrastructure: A System of Systems Approach (Hall et al, 2016; UNOPS, 2017).

The concept of a system of systems recognises that infrastructure projects in the built environment are more than the sum of their parts, albeit that the strength of their synergy also has an inherent risk of resilience weakness through both complexities and boundary management issues if they are not fully understood and managed (Davies, 2004; ITRC's Hall et al, 2016). The concept challenges the traditional understanding of infrastructure as stand-alone physical assets. The systems approach recognises a number of linear value chain connections that fit with concepts 1 and 2 described earlier. These are illustrated in Figure 28 below, showing the way that investment of resources on specified infrastructure projects deliver assets that can be transformed through programme change initiatives to provide a service to society, which if successful, has strategic impacts that could be aligned to SDGs. Thus, infrastructure operates as a set of both interrelated and interdependent systems, which enable service systems within a certain context to function. The key definitions for the infrastructure systems are (UNOPS, 2017) as follows:

- **Systems Thinking**: An approach that focuses on the identification of interrelationships between components (i.e. sub-systems) of a system (Davies, 2004). Davies argues (2004) that the provision of integrated solutions and 'systems integration' is becoming an increasingly important part of construction companies skillset. In addition to an ability to design and integrate systems using internal or external sources of product supply, these firms are developing novel combinations of service capabilities (operations, business consultancy and finance) required to provide complete solutions to each customer's needs.
- **Infrastructure System** (UNOPS, 2017; ITRC's Hall et al, 2016). '*A system comprised of assets, institutions and knowledge that provides a society its services. Examples of National Economic Infrastructure systems are: Water, Energy, Transport, Waste, and Telecommunications*'.
- **Assets** (UNOPS, 2017; ITRC's Hall et al, 2016). Adapted to: The physical components of the system. This also extends to the links that exist between the assets in the system. Note that there are man-made assets but also 'Natural Assets', which provide a service. Examples of man-made assets include roads, bridges, power lines, and pipes. Example of natural assets include wetland systems, and mangrove forests.
- **Services** (UNOPS, 2017; ITRC's Hall et al, 2016). '*The functions which the infrastructure system enables. Examples include healthcare services, transport services, and education services*'.

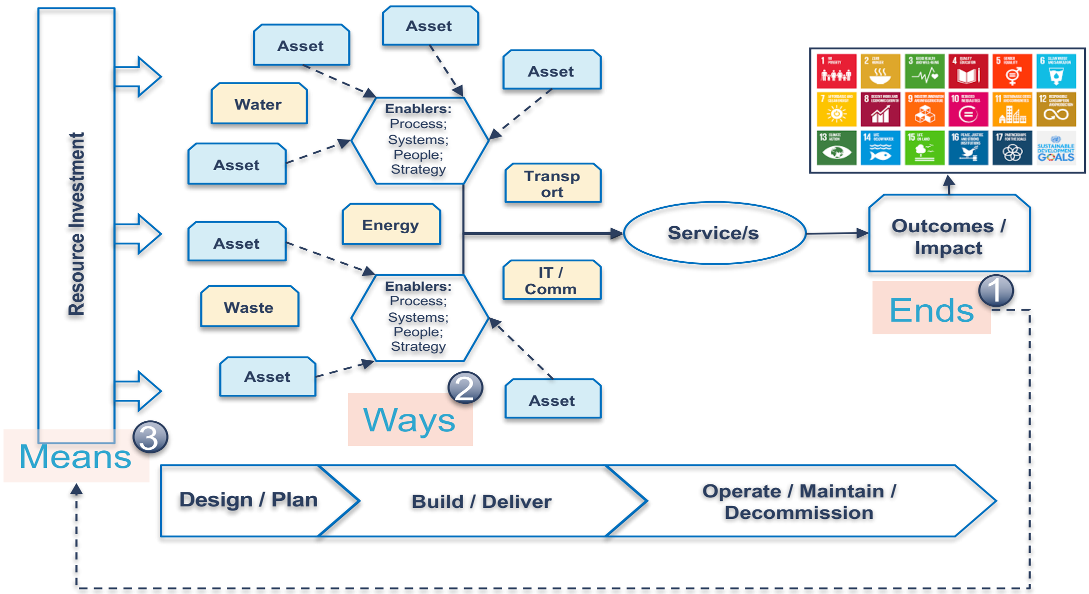


Figure 28: Infrastructure System of systems Map showing 'Ends, Ways, Means'. Adapted from papers by UNOPS (2017) and ITRC's (Hall et al, 2016).

Infrastructure projects' SDG impact is best understood through the relationship, shown in Figure 28, between the infrastructure systems' service to society. This provides the causal link to the SDG impacts and a coherent way to assess sustainability across the TBL of economic, social and environmental impact areas.

The applicability of understanding infrastructure projects within a system that delivers outcomes, is becoming better understood (Davies, 1997, 2004, 2005, 2014; ICE, 2018; National Infrastructure Commission, 2018; IPA TIP Report, 2017) as a value-based proposition, as evidenced in the ICE transformative research on Project 13 (ICE, 2018). It focuses more on wider stakeholders' social and environmental impacts as well as the business-leading economic requirements of time, cost and scope.

3.8.4 Concept 4 – Delivering Impact measured against the TBL/SDGs

The connection between the SDG impacts and the five main national economic infrastructure systems of power (i.e. energy), water (including collection, treatment, distribution, and disposal), transport, waste, and information and communications technology (ICT), is described below in the fourth concept, which illustrates the TBL link that connects the entire SDG Infrastructure Value-Impact Chain (IVC).

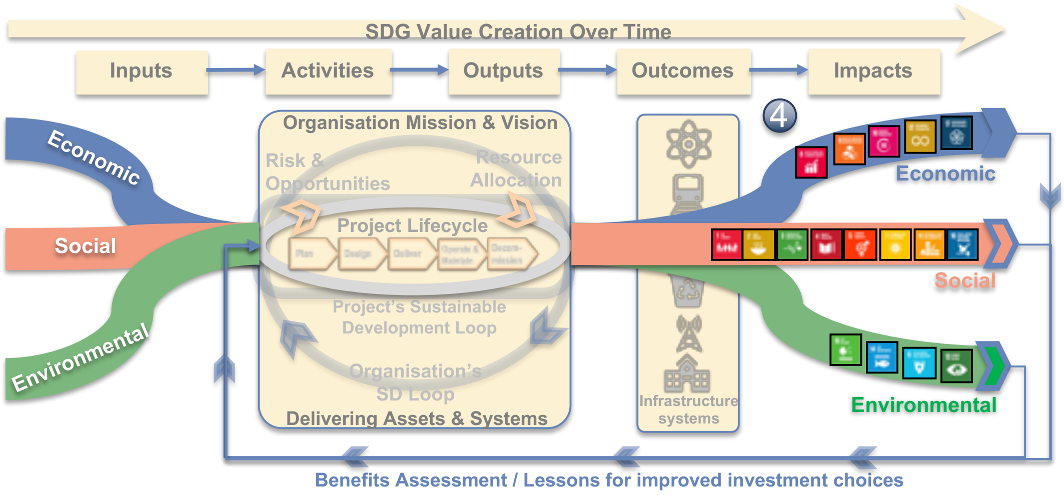


Figure 29: Concept 4 – Delivering impact measured against the TBL/SDGs, and completing the learning-loop for smarter investments, adapted from ICAS/IIRC's 'The Sustainable Development Goals, integrated thinking and the integrated report' (Adams, 2017).

3.9 SUMMARY AND IMPLICATIONS

This chapter has discussed the theoretical framework. The chapter described how the Critical Realism perspective of ideological philosophers such as Bhaskar (1978) informed the Realist Evaluation approach championed by Pawson and Tilley (2004) and this introduces the Context-Mechanism-Outcomes model that provides the overarching research framework. The chapter includes analysis of the primary theories adopted for the research, including the Theory of Change and Triple Bottom Line, which are both embedded in the proposed mechanism, called the Impact Value Chain (IVC – developed in Chapter 7) – highlighting the need for project value creation as an end product-outcome of a project (Brady, Davies & Gann, 2005). The chapter also introduces the context and mechanism across the project organisational structure developed by Müller, Drouin, and Sankaran (2019a), who proposed a layered model of organisational project management (OPM). This theoretically enables the structured evaluation of the concept of SDG, from global to local, at portfolio, mega-project and project levels.

The preceding discussion on theories has established a number of key considerations to be taken forward in this study:

- The 9 contextual variables identified in Table 7, that were developed from the systematic literature review, shown in Figure 15, identified a nodal structure of issues and variables. These were applied to the Müller OPM Onion Model (Müller et al., 2019). This provided the link to shape the evolving evidence based MISI research framework. It was used to inform the empirical evidence gathering for the surveys and the interviews. The 9 contextual variables provided a way to structure the questioning and supported the proposition analysis.

- Based on the literature review from the previous chapter and the theoretical analysis in this chapter, an initial theoretical model was developed, called the Impact Value Chain (IVC). The IVC was developed further into a prototype model for testing in Chapter 7, when the triangulation from the empirical evidence was used to strengthen the IVC model that was then tested in Chapters 8 (for a 'Golden Thread') and 9 (with a water utility company).
- The review of theories has highlighted the potential benefits and tensions of linking global goals to local delivery on infrastructure projects. As a result of these findings, the derived sub-research question that underpinned Research Objectives 1-3 [8] are:

  How do practitioners in the construction sector rate and use global UN SDGs for infrastructure investment decisions at the local level? The sub-questions that flow from this were:

  - *What contextual issues influence the successful use of an SDG measurement mechanism to achieve the desired outcomes*? (This represents the context).
  - *What mechanism (for measuring SDG impacts) is in place to achieve the outcomes*? (This represents the mechanism).
  - *What are the expected outcomes of using the SDG measurement mechanism*? (This represents the outcome).

The four propositions from Chapter 2, the variables identified in this chapter, and the three sub-questions for proposition 1 and 2, shown above, informed the design of the methodology discussed in the next chapter. As a way of building an evolving picture of how the study built its understanding to answer the research question by

[8] RO1: To understand the existing MISI knowledge (in theory and practice); RO2: To understand the MISI context (the 'variables'); RO3: To assess the current MISI mechanisms.

addressing the propositions, the table shown below will be iterated at the end of each chapter:

Table 8: Development of stability of Propositions' Results (changes since previous Chap in red)

Confidence in Evidence for Propositions	P1: Engineer's view of current MISI	P2: Organisational view of MISI	P3: 'Golden Thread' global - to - local	P4: Prototype Development
Theoretical Analysis	Not yet	Not yet	Very Low *1	Very Low *1
Survey Analysis	Not yet	Not yet	Not yet	Not yet
Interviews Analysis	Not yet	Not yet	Not yet	Not yet
Test 1: Golden Thread	Not yet	Not yet	Not yet	Not yet
Test 2: Case Study	Not yet	Not yet	Not yet	Not yet

Note *1: Table 8 above illustrates the assessment of the quality of propositions' evidence. This is based on a qualitative formula designed by the Clinical Grading Working Group's British Medical Journal's study (GRADE, 2004) that is widely used to assess the maturity of evidence underpinning propositions, based on a combination of quality and consistency. The high level of innovation needed for MISI, suggests that trialling new forms of evidence building (in this case by using a technique for building proposition confidence) is justified. The GRADE Group (2004) use the following definitions: **High**, Further research is very unlikely to change the confidence in the estimate of effect; **Moderate**, Further research is likely to have an important impact on the confidence in the estimate of effect and may change the estimate; **Low**, Further research is very likely to have an important impact on the confidence in the estimate of effect and is likely to change the estimate; **Very Low**, Any estimate of effect is very uncertain.

Chapter 4: Research Design and Methodology

4.1 OUTLINE OF CHAPTER

The research design needs to be logical, relevant and achievable (Merriam and Grenier, 2019). Research can be defined as something that people undertake in order to find out things in a systematic way, thereby increasing their knowledge (Ghauri and Grønhaug, 2005). This chapter explains the 'systematic way' chosen as being the most appropriate for the needs of the MISI study.

The basis for the choice of research method was whether it will help the study answer the research question, the research objectives and the four propositions (Table 5) established in the previous two chapters, whilst also meeting the key criteria of 'logical, relevant and achievable' (Merriam and Grenier, 2019). This chapter also explains how the derived analysis from the earlier chapters has informed the research design and methodology for this Sequential Explanatory Design (Creswell, 2017) that uses a mixed methods study of surveys and interviews to address Proposition 1 and 2 (Table 5) – gaining insights to individual engineers' and organisations' perceptions of approaches to MISI. A more detailed analysis of the research setting, and the sample population is completed in the following two chapters (surveys in Chapter 5, and the interviews in Chapter 6), covering the design, results and discussion, relevant for each approach.

4.2 METHODOLOGY

Using the C-M-O theoretical lens discussed in the previous chapter, an iterative research framework was developed that combined a mixed-method design, shown below in Figure 30, and discussed at length in Section 4.3. The research design involved a three-way data collection approach. At its core, the research design built on the triangulation of qualitative and quantitative datasets, which is well recognised as a method for informing theory-led research development (Creswell, 2017; Easterby-Smith et al., 2002). In what Creswell (2017) describes as a Sequential Explanatory Design, the literature review informed the survey questions and analysis that iteratively then informed the structure and approach of the interviews. In this way, Merriam and Grenier (2019) suggest that 'the interviews help the researcher understand the responses to the survey as well as provide additional insights into the phenomenon of interest'.

As shown in Figure 30 below, the development of a prototype SDG measurement model was based on the triangulation of learning from the literature review, the survey of 325 engineers and the subsequent interviews of 40 senior executives. A primary advantage of combining the survey with the semi-structured interview method is that it allows an adaptive-responsive approach to ensure the best improvisation to delve deeper into relative areas of importance, based on the Participant´s survey responses (Hardon et al., 2004, Rubin & Rubin, 2005, Polit & Beck, 2010) and it also allows for interview participants' verbal expressions to be captured (Robert Wood Johnson Foundation, 2008).

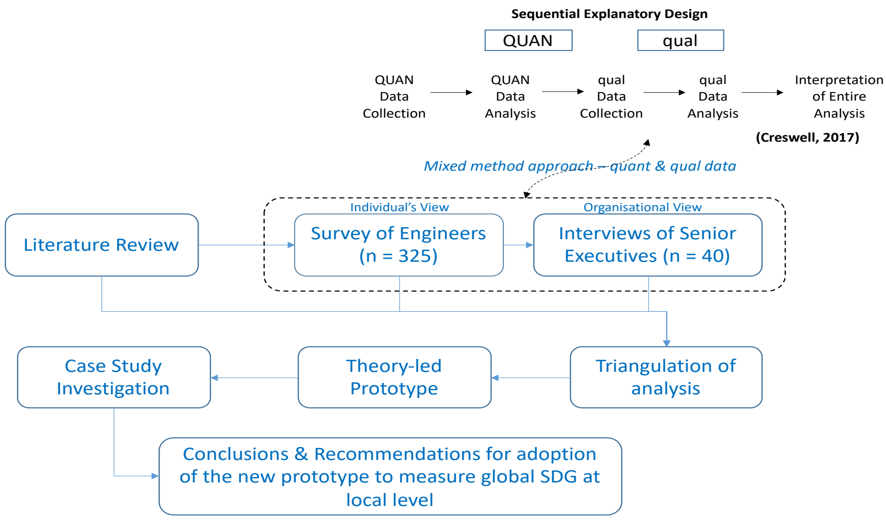


Figure 30. The mixed-method research design adapted from Creswell (2003 and 2017).

The research methodology shown above combines both inductive (interviews) and deductive (literature review and survey) enquiries. This provides a sequential two stage testing of the propositions, firstly by the conduct of a survey to get individual engineers' views on MISI (Chapter 5), then subsequently, through learning from the survey, to develop a deeper and richer understanding of the research phenomenon by completion of 40 interviews (Chapter 6). Both methods, linked explicitly to the research question, addressed the first two propositions, with the final two propositions being addressed in the Case Study 2-Test stage (Chapters 8 and 9). In particular, Chapter 8 and Chapter 9 provide evidence that a link can be made from global to organisational level. The two chapters highlight the importance of strategically defining their organisational outcomes and strategic interventions in a structure and language that aligned to the SDGs (as shown in Table 31 and Figure 72). For example, Anglian Water used the SDGs to illustrate the strategic priorities that the organisation set as part of its long-term goals (selecting 10 SDG goals and 35 targets to measure their success). The strategic intervention was managed by Anglia Water's portfolio office that used the defined SDG goals and targets to map the delivery pathway at project level in the delivery phase.

4.3 RESEARCH DESIGN

The research was based on two main stages. The first stage, informed by a systematic literature review, comprised a mixed method that involved a survey of 350 engineers (due to late completion of 25, only 325 were included in the analysis) to derive quantitative data (Mansell et al., 2020b) along with interviews with 40 CEOs and corporate Heads of Sustainability to capture qualitative data (Mansell et al., 2020c). The second stage involved the development of a prototype that was tested through further exploratory investigations at two levels: (1) Test 1: is there a Golden Thread from global SDGs, through the organisational-level, down to project level SDG impact measurement; (2) Test 2: does the prototype model, the *Impact Value Chain*, have coherence in the analysis of a brief case study investigation that, through application of the main findings from the empirical stage, evaluated the scope to measure SDG performance for infrastructure projects at a Water Utility Company (Anglian Water) (Mansell et al., 2020d). Subsequently, the research study led to a collaborative partnership to test the protoype model and its approach across the Environment Agency's full portfolio of projects and also, the megaproject of the Thames Tideway Tunnel (supporting letters describing the direct impact of this follow-on stage are evidenced in Appendices 17-23).

4.3.1 Research 'Onion Ring' Framework

The Saunders 'research onion ring' (Saunders et al., 2009), originally developed in 2007, provides a common framework to explain this study's approach to the theoretical and methodological positions.

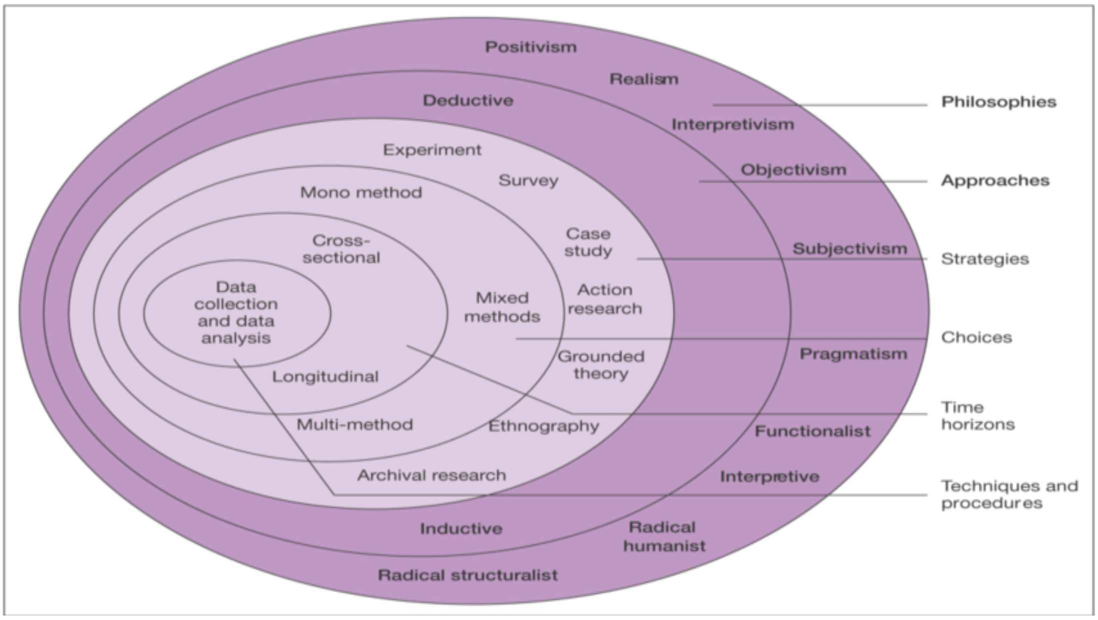


Figure 31. The Research 'Onion Rings' (Saunders et al., 2009).

The previous chapter described Level 1 of the 'Onion Ring', the philosophical stance, and this chapter deals with the other five layers: Approaches; Strategies; Choices; Time Horizon; and Techniques and procedures. The detailed design of the Survey Stage is covered in Chapter 5, and for the Interview Stage, in Chapter 6. The high-level summary of the choices of design approach for each of the 6 research strategies shown in column 'a' in Table 9 (Saunders, 2007) is shown below. The columns iteratively illustrate the methodology design, starting with the research design in column 'b', listing whether it was primarily a deductive or inductive method. Column 'c' lists the derivation of the input design, providing clarity on how the research strategy was structured to 'give meaning' to the phenomenon of interest (Merriam and Grenier, 2019). Columns 'd' and 'e' list the propositions and research objectives that are addressed, which is shown as a percentage completion in a table at the end of each of the research strategy chapters (2,3,5,6,7,8, and 9) to enable the reader to follow the evidence-building along a recognisable analytical linear pathway. Column 'f' details the method and tools used, such as SPSS and NVivo, and the final column 'g' lists the outputs from the specific research strategy, for example, the four propositions are an output from the SLR in Chapter 2.

Table 9: Development of methodological design based on Saunders' Research Onion Ring (2009)

Research (a) Strategy: (Saunders, 2009)	**Research (b) Approach:** Deductive / Inductive	**Input Design (c)**	**Propositions addressed (d)**	**Research Objectives addressed (e)**	**Data Collection Methods & tools (f)**	**Outputs (g)**
Literature Review (Ch 2)	Deductive	PRISMA (Liberati et al., 2009) checklist	n/a: SLR led to derived propositions	RO 1 - 2	Excel and interpretive deduction	4* Propositions;
Theory (Ch 3)	Deductive	Research Question and Res. Objectives	Proposition 4 (partly)	RO 1 - 3	Literature investigation with Excel	9* Context variables; 4* sub-questions for data collection on P 1 & 2; Informs RO 5 & 8
Survey (Ch 5)	Deductive	8 process steps: Creswell, 2017; 9 Context variables	Proposition 1	RO 1 - 4	SPSS	Informs RO 5 & 8
Interview (Ch 6)	Inductive	Updated 9 Context variables	Proposition 2	RO 1 - 4	NVivo	Informs RO 5 & 8
Case Study (Ch 8) Test 1: GRI & CEEQUAL	Inductive	Case Study 5 tests (Flyvbjerg, 2006)	Proposition 3	RO 6	Excel and NVivo	Informs RO 8
Case Study (Ch 9) Test 2: Water utility company	Inductive	Case Study 5 tests (Flyvbjerg, 2006)	Propositions 1, 2, 3 and 4	RO 7	Interpretive induction with Excel	Informs RO 8

List of Propositions: **Proposition 1**: Individual engineers are 'supportive but frustrated' in methods to measure global SDG goals at project level.; **Proposition 2:** Organisations' leaders champion SDG measurement without having evidence-based methods to verify claimed impact at portfolio and project levels; **Proposition 3**: Current sustainability measurement at organisational and project levels can be used to demonstrate a 'golden thread' from 'global' SDG to 'local' portfolio and project levels.; **Proposition 4**: A MISI prototype can provide a plausible, testable and achievable logic chain for defining project and portfolio SDG impacts.

List of Research Objectives (RO): **RO1**: To understand the existing knowledge on how organisations and projects measure infrastructure projects' SDG Impact; **RO2**: To understand the context of the current use of mechanisms to measure infrastructure projects' SDG Impact; **RO3**: To assess the current mechanisms used for the Measurement of Infrastructure projects' SDG Impact (MISI) at portfolio and project levels; **RO4**: To understand the perception of individual engineers and organisations' relative perception of the outcomes of the current use of mechanisms to measure infrastructure projects' SDG Impact; **RO5**: To use the theory-led study to inform the development of a prototype model to improve the measurement of infrastructure projects' SDG Impact; **RO6**: To test whether a 'golden thread' of SDG measurement could be identified from global to local levels; **RO7**: To test whether the prototype could be validated with a case study organisation; **RO8**: To build a framework for further development, for researchers and practice to utilise, driving improved investment decisions across planet, profit and people outcome criteria, aligned to SDG impacts.

Note: the compilation of the results against all the propositions and research objectives are included in the final chapter's summary of results.

Based on the research question, the research objectives and the propositions to be tested (as shown above in Table 9), the research uses the Critical Realist Evaluation methodology, introduced in the previous chapter, first developed by Pawson and Tilley (1997). The separate investigations needed to be set-up in a way that could analyse workings of recognised sub-systems within the programme (the measurement of SDG impacts on projects) being investigated, and in doing so, create events that the participants could express an opinion on what they observed and felt. Thus, the realist evaluation approach provides data that indicates how the intervention works (the generative mechanism) and also helps identify the conditions that are needed for a particular mechanism to work (i.e., specification of contexts).

Secondly, the choice of the research strategy was influenced by the need to ground theory in practice, which was highlighted in the previous Systematic Literature Review in Chapter 2 that concluded many studies into SDG at project level were too theoretical, lacked insights for practitioners to apply, and were without tools and models that could be tested.

4.3.2 Critical Realist (CR) Research Designs

A summary of the CR design choices for the MISI study are shown in the table below (Table 10). This design, adapted by Vincent and O'Mahoney (2018), uses the CR structure devised by Ackroyd and Karlsson (2014). The table illustrates two design considerations, the first (shown in columns under 'a'), corresponds with the research focus, scaling from intensive research to extensive research. Intensive research emphasises qualitative research designs, such as case-studies. Extensive research investigates the impact of context variables on a mechanism, such as by using surveys (Sayer, 1997). For example, quantitative data from the survey of the engineers can be used to generate taxonomies for the coding of the interviews and is useful more where mechanisms are known (or at least inferred) but the context varies (Ackroyd and Karlsson, 2014). The second design criteria, shown in rows 'b' and 'c' below (Table 10), reflects the relative detachment of the researcher, either from a distance, or whether they are trying to manipulate the mechanism or context under investigation (Vincent and O'Mahoney, 2018).

Table 10: Critical Realist Research Designs (amended from Vincent and O'Mahoney, 2018; Ackroyd and Karlsson 2014)

	Intensive ←→ Extensive (a)			
	What is the mechanism?	*How do context & mechanism typically behave x OPM levels?*	*How do context & mechanism historically interact?*	*What are the context variables that impact outcomes?*
Detached (b)	Case-study (Chap 9)	Comparative case-study (Not used)	Institutional / historical analysis (Not used)	Surveys (Chap 5)
Engaged (c)	Action research (Not used)	Intensive realist literature evaluations (Chaps 2,3 & 7)	Barefoot research (Not used)	Extensive realist evaluation (Chap 6)

Based on this CR framework, the proposed future research design methods chosen, with corresponding literature provenance, were:

- **Case-study**. The most frequent form of CR research that enables MISI to test the exploration of using the IVC prototype to assess whether it is practical, plausible and achievable. Beynon (1979), Flyvbjerg (2006), Ruddin (2006) and Gouldner (1964) suggest this enables the researcher to abduct causal mechanisms from their empirical evidence. Chapter 9 used this design.
- **Action research**. This is described by Friedman and Rogers (2009) as '*a research investigation to explore the workings of a mechanism by triggering it or changing its context*'. Cassell and Johnson (2006) and Morgan and Olsen (2008) also champion this approach. This method of research was discounted due to a lack of time, resources and buy-in from potential organisations to develop the approach with, but is considered for the follow-on research, discussed in Chapter 10.
- **Comparative case-study**. The proponents of this approach such as Kirkpatrick et al. (2005), and, Delbridge (1998) suggest this as a suitable way to explore how similar mechanisms operate in different contexts. This was not chosen as an approach but is considered for the follow-on research to select organisations that can be evaluated at a portfolio and project level, and perhaps one megaproject.

- **Intensive realist literature evaluations**. This supports the explanation of what mechanisms work in different contexts by reviewing the extant literature, as described by Marchal et al. (2012). It is used in Chapters 2, 3 and 7 to build theoretical underpinning to the prototype model.
- **Institutional / historical analysis**. Clark (2012) and Mutch (2007, 2013, 2014) propose this as a way to examine causal chains over time to explore how mechanisms and contexts interact over time, and the conditions for such interaction (Smith and Meiksins, 1995). This longitudinal approach has not been used because of the challenge of the researcher's time and resources.
- **Barefoot research**. Lindqvist (1979, 1995), and more recently Vincent and O'Mahoney (2018), describes how organisations can '*develop their own interpretations by use of training and encouraging employees of the case study organisation to do their own research*'. This is the approach that might be used for future research since it requires the training of the collaborative MISI partnership for them to conduct their own review and further developments.
- **Surveys**. Cully et al. (1999) and others (Rea and Parker, 2014; Vaske, 2019; Groves et al, 2011) characterise this approach for '*when the primary focus is on descriptive statistics*' (such as sampling from the population data of the Institution of Civil Engineers in Chapter 5) to investigate the empirical impacts or conditions of using the MISI mechanism. This study uses it to prompt explanatory investigations, that informed the interviews (Chapter 6).
- **Extensive realist evaluation**. The mixed methods approach in an 'engaged' way, partly reflects the Interviews approach described in Chapter 6, that is informed by survey's statistical techniques to examine how different contexts affect a mechanism (Kazi et al., 2002, Kazi, 2003).
- **Methods not used**. There were four methods not used for the research. This was for reasons of either non-applicability or because of time and space limitations (being a single researcher). However, these research methods have been re-considered for future research and these proposals are discussed in the final chapter (see Table 37).

4.4 QUALITATIVE OR QUANTITATIVE, OR BOTH?

Ultimately, the choice of method needs to fit with the research question, which is based on the problem definition (Creswell, 2003). Creswell develops this by stating that mixed methods should only be chosen '*when qualitative or quantitative research is insufficient to fully understand the problem*'. Creswell further expands this statement in five ways: '*we need to explore before we administer instruments*'; '*we need to explain our statistical results by talking to people*'; '*we need to see if our quantitative and qualitative results match each other*'; '*we need to enhance our experiments by talking with people*'; '*we need to develop new instruments by gathering qualitative data*'. The following two sections will answer these five statements.

4.4.1 What type of data and analysis will I need?

Based on the Creswell's definition questions (2003) in the previous paragraph, the data requirements of this study, to meet the research objectives, are:

- Quantitative data collection (closed-ended).
    - To capture individual engineers' perceptions on the following sub-questions: *How do practitioners in the construction sector rate and use global UN SDGs for infrastructure investment decisions at the local level*? The sub-questions (SQ) that flow from this are as follows:
        - SQ1 - What contextual issues influence the successful use of an SDG measurement mechanism to achieve the desired outcomes? (This represents the context);
        - SQ2 - What mechanism (for measuring SDG impacts) is in place to achieve the outcomes? (This represents the mechanism);
        - SQ3 - What are the expected outcomes of using the SDG measurement mechanism? (This represents the outcome).
    - The chosen instrument is a survey, using a Likert scale to collate quantifiable perceptions on relevant criteria.
- Quantitative data analysis

    - To use numeric data to provide: description of the phenomenon of study; comparison of groups; and for relating the contextual variables identified in Chapter 2. The SPSS tool was used to support statistical analysis.
- Qualitative data collection (open-ended)
    - Using the same sub-questions discussed above, the chosen instrument was to set-up interviews with senior executives, supported by supplementary reading of their organisation's reports and publications, to get an organisational perspective.
- Qualitative data analysis
    - Use text and image data to allow: coding; theme development and for relating themes to the propositions; and, enabling the MISI contextual variables to be analysed in a richer-deeper analytical way, by building on the survey through semi-structured interviews. The NVivo tool was used to support qualitative analysis.

4.4.2 Rationale for mixed methods

Based on the discussion above, the reasons for using the mixed methods was the need for different, multiple perspectives to achieve a more complete understanding. This enabled the interviews to confirm and expand on the results of the survey. In doing so, the two-step Explanatory Sequential Design (Creswell, 2015; Merriam and Grenier, 2019), illustrated in Figure 32 below, built on the first data analysis by: informing the design of the interviews (by closing data gaps); testing emerging trends, better contextualising the approach to the CEOs, by sharing with them the results of the survey, thus gaining credibility and increased likelihood of being given their 'precious time'; and allowing the researcher to mature his skills as part of Kolb's (1981, 1984) Experiential Learning Cycle theory, in which the researcher has time to 'experience, reflect-observe, conceptualise, and experiment'.

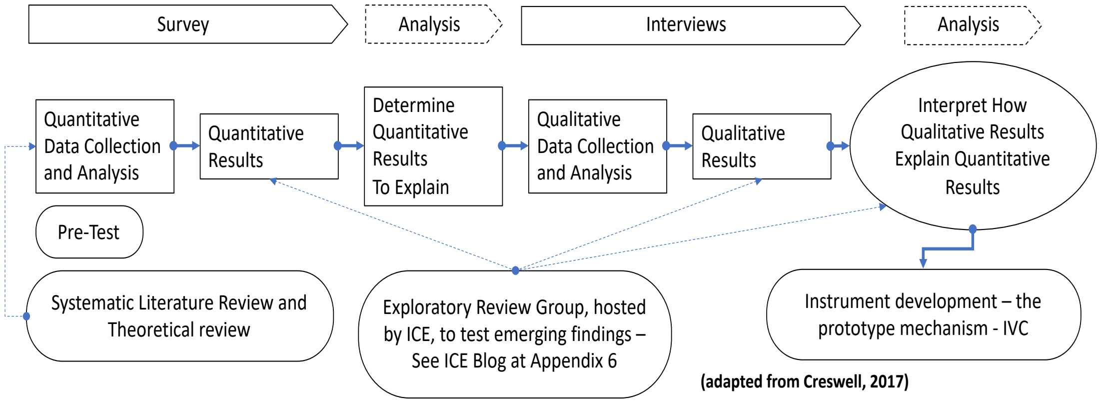


Figure 32. The two-step Sequential Explanatory Design adapted from Creswell (2003 and 2017).

4.4.3 Building the CMO Configuration

The first step (of the two-steps in Figure 32) clarifies the programme of intervention (measuring SDG impacts) to be investigated and identifies the core issues within the three C-M-O elements (Pawson and Tilley, 2004; Zachariadis et al., 2013). Having listed the primary elements of CMO (based on earlier surveys, interviews and literature review), the C-M-O configuration was designed as a routemap to identify a propositioned causal chain that could be interrogated, with the ultimate purpose being to consider whether the IVC was usable by practitioners, and in what circumstances it was likely to be successful. The Figure 33 below illustrates the causal pathway C-M-O and shows in red, the primary areas of the investigation.

The two diagrams below (Figure 33 and Figure 34) provide a way to understand how the three lenses of C-M-O have materialised into: (1) the context variables extracted from Muller et al. (2019); (2) the mechanism from the theoretical analysis of ends-ways-means; and (3) the outcome criteria are from the Theory of Chain evaluation, and investigation into definition of project success.

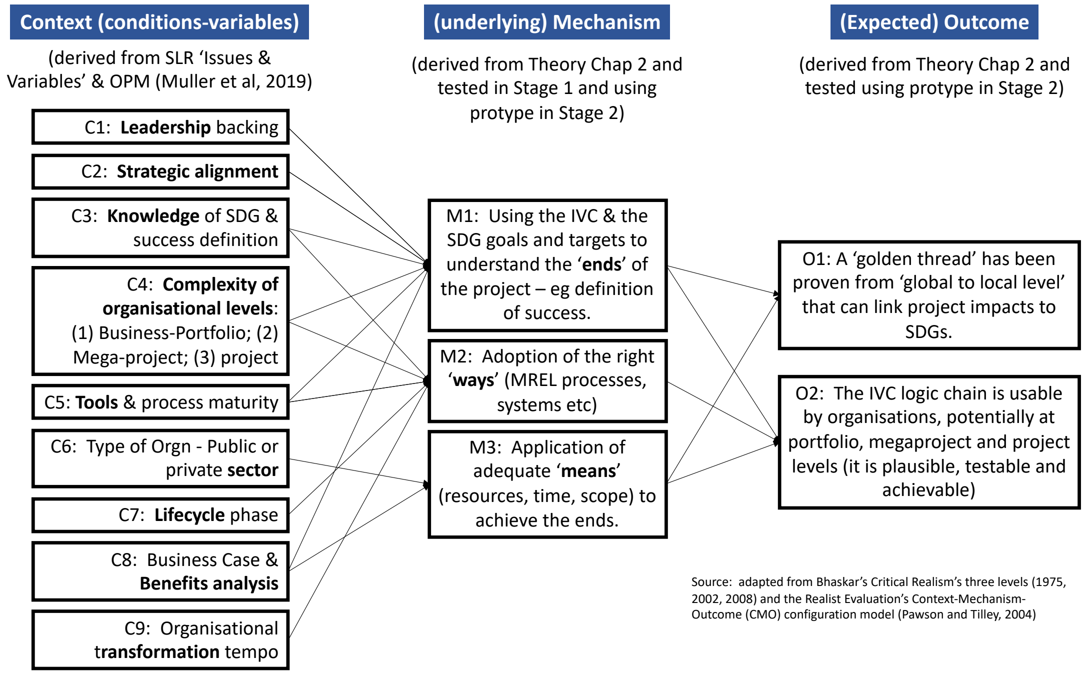


Figure 33: The Context-Mechanism-Outcome Variables Framework's causal pathway.

This can be simplified as a conceptual model that shows the relationship between the core areas to be investigated: the Realist Evaluation's Context-Mechanism-Outcome (CMO) configuration model championed by Pawson and Tilley (2004) and widely used across clinical research (Pawson, 2005); the Impact Value Chain as the central 'mechanism' being investigated; across the three levels (from Muller's OPM) of the project, mega-project and portfolio.

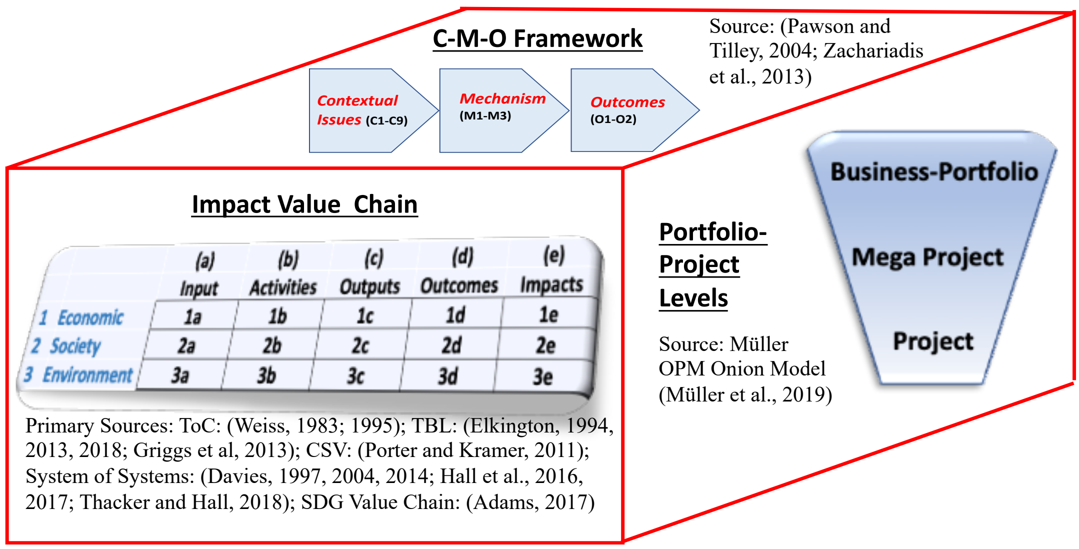


Figure 34: Simplified conceptual view of analytical model for testing the propositions across three dimensions of: IVC; C-M-O Framework; and Portfolio-Project Levels.

4.4.4 Stage One – Exploratory Investigation

The Exploratory stage of the investigation sought to identify the 'landscape' of the phenomenon of interest. Through the iterative stages of research, shown in Figure 35, the purpose was to address a gap in knowledge through a series of events that enabled the gradual deepening of understanding and thereby, to address the research question as well as the propositions.

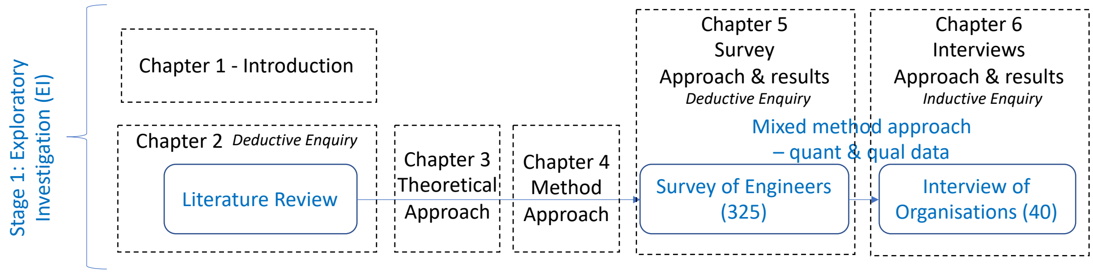


Figure 35: Exploratory Investigation (EI) Flow Chart.

4.4.5 Stage Two – Detailed Investigation

The Detailed stage of the investigation sought to build on Stage One by firstly triangulating the data and analysis from the literature review, the survey and the interviews, and secondly, to build a prototype model that could be tested. Through the iterative stages of research, shown in Figure 36, the purpose was to address a gap in knowledge through a series of events that enabled the gradual deepening of understanding and thereby, to address the research question as well as the propositions.

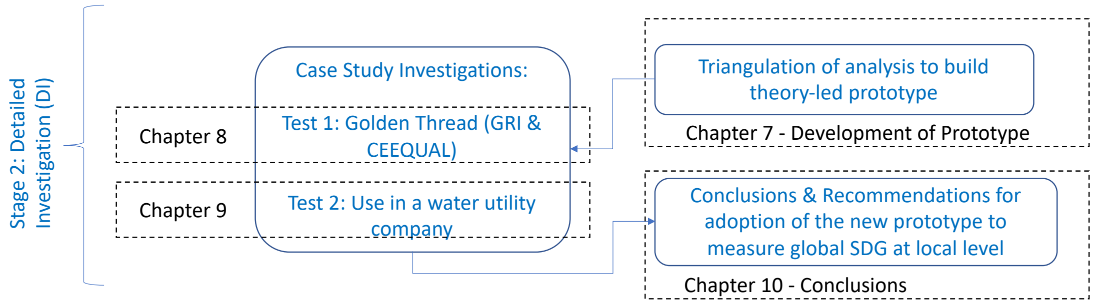


Figure 36: Detailed Investigation (DI) Flow Chart.

4.4.6 Quantitative Research Method – the survey (see Chapter 5)

A survey of 325 engineers on what the individual engineers' perspectives on the research question provided the data source to inform the secondary step of the qualitative research method. A detailed description of this event is in the next chapter.

4.4.7 Qualitative Research Method – the interviews (see Chapter 6)

A series of 40 interviews were conducted to provide an organisational perspective on the research question. The approach was informed by the preceding quantitative research method. A detailed description is in Chapter 6.

4.4.8 Triangulation of Data (see Chapter 7)

Triangulation has been used extensively in qualitative and social research. The thinking behind triangulation was introduced by Norman Denzin (1970) in the 1970s who developed the proposals by Webb et al. (1966) and before them, Campbell and Fiske (1959). The premise is that by adopting the maritime usage of triangulation, which uses the reading of stars through astral navigation, to produce a triangle that identifies the users' location, a similar approach is used for research. Thus, triangulation is a method that can improve the validity (extent to which a study accurately reflects or evaluates the concept or ideas being investigated) and credibility (trustworthiness and how believable a study is). Thus, the method design included an Explanatory Sequential Design (Creswell, 2015; Merriam and Grenier, 2019), followed by a triangulation of data to inform the development of the prototype.

4.5 ETHICS AND LIMITATIONS

The ethical considerations of the research and any problems and limitations, as well as any anticipated or actual threats to the validity of the results are described in detail in Chapters 5 and 6.

4.6 CHAPTER CONCLUSION

This chapter has chosen a research design to be logical, relevant and achievable (Merriam and Grenier, 2019). It has described the 'systematic way' that it intends 'to find out things' (Ghauri and Grønhaug, 2005) in the most appropriate way to meet the needs of the MISI study. This chapter also explained how the derived analysis from the earlier chapters has informed the research design and methodology for this Sequential Explanatory Design (Creswell, 2017) that uses a mixed methods study of surveys and interviews to address the propositions. A more detailed analysis of the research setting, and the sample population is completed in the following two chapters, covering the design, results and discussion of the surveys in Chapter 5, and the interviews in Chapter 6.

Chapter 5: Survey Method, Results and Analysis

5.1 OUTLINE OF CHAPTER

This chapter describes the design adopted by this research to achieve the aims and objectives stated in Chapter 1. Section 5.2 discusses the methodology used for this first part of the Sequential Explanatory Design (Creswell, 2017), the survey of 325 engineers, the stages by which the methodology was implemented, and the research design; Section 5.3 details the participants in the study; Section 5.4 provides the survey results that feed into Section 5.6 inferential statistics. The discussion is included in Section 5.7, with the policy implications outlined in Section 5.8.

5.2 METHODOLOGY AND RESEARCH DESIGN

5.2.1 Methodology - Using the Realist Evaluation Methodology to Structure the Survey

As discussed in Chapter 3, the research study adopted the Critical Realism perspective of philosophers such as Bhaskar (2013) to inform the choice of the Realist Evaluation approach, primarily because of its practical utility and its widespread use in social science research into the impacts of programmes (Linsley et al., 2015). Pawson and Tilley specifically recommend the C–M–O strategy so that 'programme theories can be tested for the purposes of refining them' (2005, p. 2). In this regard, the investigation was not about what works but asks instead, 'what works for whom in what circumstances and in what respects, how?' (2005, p. 2).

The survey captured the first-level 'empirical' observed and experienced views of engineers' use of SDG measurement by seeking to quantify their perspectives on three areas: (a) the value and importance they placed in defining SDG outcomes as a measure of project success, (b) their insights into the use of the mechanism (the 'trigger' being the tools, process, structures and strategy for measurement of a prioritised list of SDG goals and targets at the project level) and (c) the context of issues that affect the likely success of achieving the outcomes from the use of the mechanism.

5.2.2 Research Design of the Survey (expanding from Chapter 4)

Building on the high-level research programme's research design described in the previous chapter, this section describes the research design specifically of the survey.

Given the issues identified in the literature review, the methodology needed to be suitable to address the earlier stated research question: How do engineers in the construction sector rate and use global UN SDG goals for businesses and projects at local level? An online survey was used as the first part of a mixed methods approach that provides a triangulation (Creswell and Cresswell, 2017) of data (i.e., through literature review, survey and interviews) to inform the development of the prototype SDG Measurement Model. In this way, in what Creswell (2017) describes as a Sequential Explanatory Design, the literature review informed the survey questions and analysis, that sequentially informed the structure and questions of the interview stage. Creswell (2017) suggested that this sequential approach has the benefit of being the most straightforward in its design because there are discrete stages that are easy to describe and to report. The main difficulty is the length of time in the data collection phase.

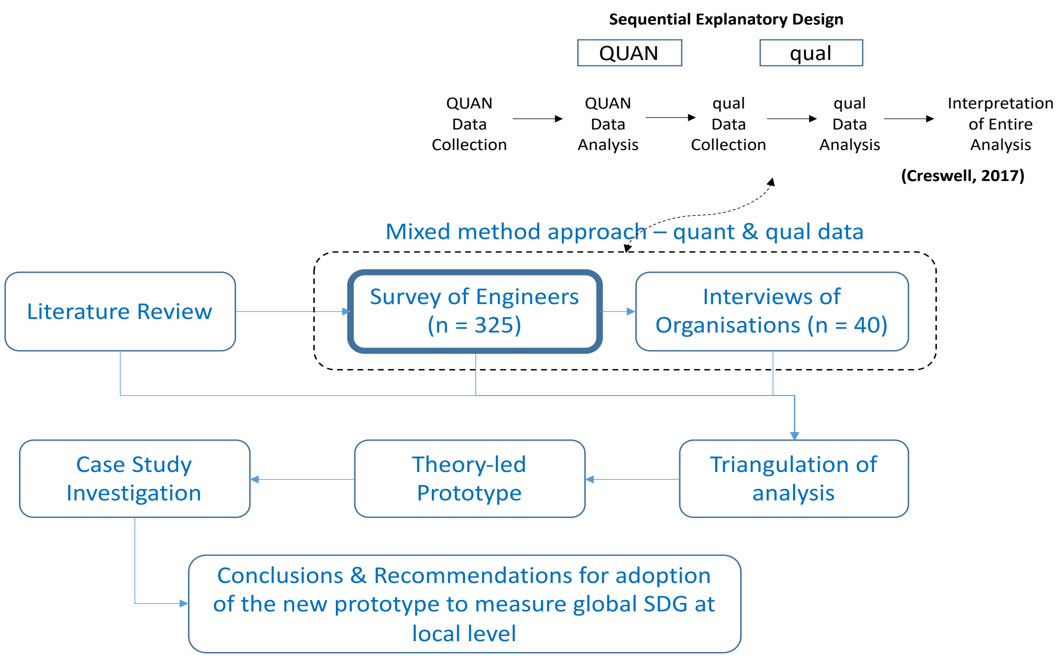


Figure 37: The research approach of mixed method Sequential Explanatory Design, adapted from Creswell (2003 and 2017).

5.3 THE SURVEY

The survey approach to data gathering was selected because it is recognised (Lenth, 2001) as one of the most important methods in applied social science. This approach, shown in Table 11, enabled a rapid and cost-effective way to assess a statistically significant group of engineering project managers' perceptions of the relative importance and current capability for measuring SDG impacts on their projects. The participants were all members of the UK's leading civil engineering professional society, the Institution of Civil Engineers (ICE), who sanctioned the survey and provided access to their members' contact details. A benefit of using this style of survey approach is that it delivered both qualitative research outputs, by using open-ended questions that captured text-based commentary, and quantitative research outputs, by using a Likert scoring mechanism aligned to the questions. The eight-step model used to structure the survey is described below in Table 11.

Table 11: Survey analysis method (based on: Creswell and Creswell, 2017; Nardi, 2015).

Survey Design and Analysis Methods		
1	**Problem specification & Research Question**	As captured in the introduction paragraph of this chapter; formulation of problem and objectives.
2	**Population Definition**	With support from the Institution of Civil Engineers (ICE); seeking a representative sample from across the engineering community.
3	**Selection of Mode**	Use of Survey Monkey © software tool—for design and running of survey data collection. It also provided statistical analysis, supported by SPSS.
4	**Design Instrument**	Identify types of questions aligned to the Realist Evaluation C–M–O approach; draft of the expected results to assess whether the design would achieve the outcomes; draft the questions on Likert scale; use closed and open questions selectively; test the approach with experts.
5	**Specify and test survey Procedure**	Build the logic framework in the tool and run 'check tests' with informed analysts to ensure the technical success and the logic of the procedure.
6	**Data Collection**	ICE distributes the survey to 1500 of its members; 325 complete the survey, ca. 20% response rate, providing representative sample.
7	**Analysis**	Completed in four stages of diagnostic analysis: **Stage 1**: Download all data (quantitative and qualitative) in MS Excel™; remove erroneous and false data, e.g., delete test data from the pilot. Structure data for analysis—e.g., charts and graphs to visualize data. **Stage 2**: Use software tool on survey monkey and SPSS to analyse the data's statistical significance; identify patterns and gaps/overlaps against research question's objectives. **Stage 3**: Analyse data touch points (using C–M–O coding) and correlate findings to the original research question and the C–M–O model. Complete initial write-up for review. **Stage 4**: Share data findings with expert panel (of 12 qualified engineers) organised by the ICE; test the findings; keep integrity of the data but use expert panel to assess the implications and possible next steps. For example, the panel suggested that the low level of organisational responses could be addressed in the

		interview stage of the research. (Note: The three separate workshops were recorded. An example of a Blog written by the ICE Knowledge Manager about the Control Group, is shown at Appendix 6)
8	**Reporting**	**Step 1**: Build the data charts that illustrate the findings. **Step 2**: Write up the findings: test and adjust to ensure recommendations and conclusions are consistent with original research question; identify lessons and insights that inform the next stage of research—the 40 interviews.

The questions (shown in Figure 38 and Appendix 3) were structured to measure attitudes in relation to the research question. The questions focused on three areas: the perceived value and importance of measuring SDGs on their projects (i.e. the outcomes); their current approach and capability (i.e. the mechanism), such as skills, tools, processes, structures and methods (Astbury and Leeuw, 2010: 386); and, their identification of the challenges and opportunities (i.e. the context) of measuring projects' SDG impact. SurveyMonkey© was chosen as the web-enabled survey tool because it was highly customisable and provided a comprehensive set of back-end capabilities, such as data analysis and visual representation tools, that helped present the data in a concise and informative manner.

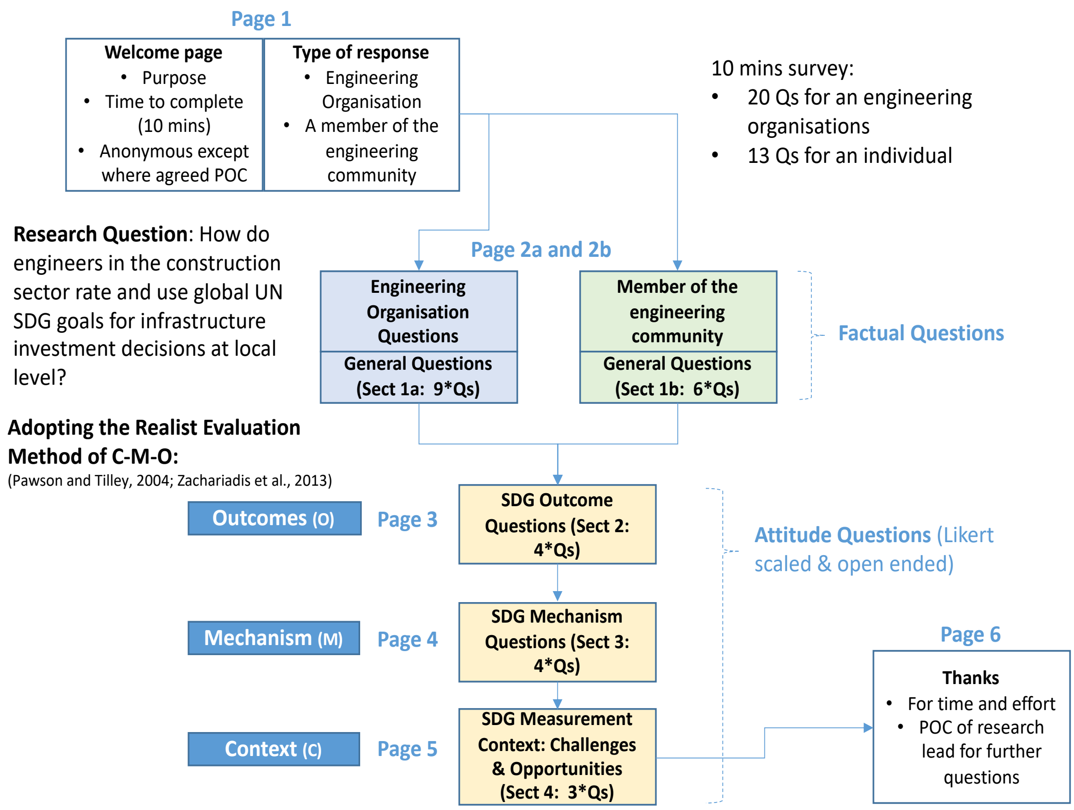


Figure 38: Survey Questions Sequence; adopting Realist Evaluation methodology of Context-Mechanism-Outcomes (Pawson and Tilley, 2004).

The tool also provided guidance on bias-elimination and sample-selection best practice. This enabled a structured approach for presenting the questions, which were designed to capture the required data. This sought to establish whether this research area was of perceived importance to practising professionals, and if it was of high importance, was there a gap between the import of measuring SDG impact versus their capability to do so? It achieved this by using both open-ended and closed questions within a clear structure that explored firstly broader and secondly, more specific areas and concepts within the research areas. The survey was sent to participants by the UK's leading civil engineering institution, the ICE, thereby providing reassurance to the participants since they would recognise the institution's name and logo, which would be likely to increase the response rate. Data protection methods fulfilled ethical and legal data management requirements, including GDPR (general data protection regulation). For example, by sending the survey from the engineering institution to their members, the approach conformed with the members' original opt-in agreement to receive similar knowledge-sharing initiatives.

5.3.1 Access

The survey aimed to access between 200–300 qualified engineers. In actuality, the Institution of Civil Engineers' communications team selected a random representative distribution of its members, aiming to achieve ca. 20% of a total number of 1500 targeted participants. Since the respondents voluntarily opted in, this was considered a non-probability sample, which Tansey (2007) suggests is preferable because it identified what he terms 'elite interview subjects' in order to avoid the randomness of generic sampling. The response rate of 325 completed surveys was relatively high by the ICE's previous experience of surveys, typically achieving only 5% to 30% responses, the latter higher response rates being due to well-publicised events, such as committee elections. In this case, the ICE only sent a single email without any follow-ups; therefore, the response rate was considered good. The ICE also confirmed that the sub-set of the 325 respondents from the 1500 targeted participants was representative of the wider membership population (of 6500) because it included a sample selection across all experience levels, from student to engineers with over 20 years of experience, and this added to the statistical validity of the sample.

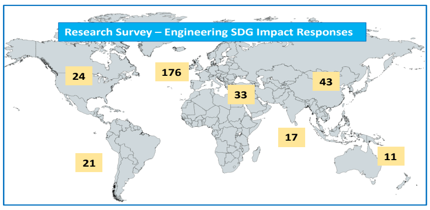
The questionnaire included a question on demographics designed to distinguish between the generations and, more specifically, capture the responses of millennials (i.e., people born between 1983 and 2000) (US Public Interest Research Group 2016; Howe and Strauss 1991) who, according to the U.S. Bureau of Labor Statistics (Labor 2017), within the following two years, reflected 50% of the US workforce, growing to 75% by 2030. The millennials can be viewed as the generation who are rapidly becoming the organisational leaders and already acting as policy shapers (Baird 2015), which is relevant to this study as they will increasingly be owning the selection and reporting of SDG priorities on their projects.

5.4 DATA ANALYSIS AND RESULTS

5.4.1 Descriptive statistics

Using an anonymous data collection approach, 325 survey responses were received during June 2018; 24 of which were corporate responses, with an average completion time of 7 minutes. There was a minimum of 159 answers for each survey response from individuals. From the 301 responses from individuals, 81% (243) were from qualified engineers, of which 45% had over 20 years of experience. When all the years of experience were added together it provided a cumulative total of 3,628 years of professional engineering expertise, not including the non-engineers that covered professions ranging from lawyers, investment specialists and academics. This indicates that although the total number of survey respondents was limited to the 325, it did include a high level of expertise that adds to the weight and power, and thus, validity for the research findings (Diekhoff, 1992). The descriptive statistical data is shown in the tables and charts in Figure 39. Also, the data showed that 40% of the respondents were millennials.

Europe	176 responses
Africa	0 responses
Middle East	33 responses
Indian Sub-continent	17 responses
Asia	43 responses
Australasia	11 responses
North America	24 responses
Latin America	21 responses

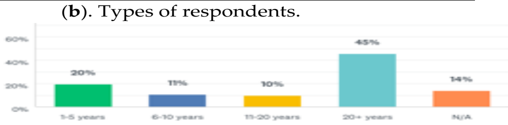


(a). Geographical region.

Qualified engineer	81%
Engineer working towards chartered status	4%
Student engineer	10%
Academic / educator	2%
Supply chain	0%
Related engineering business	3%

(b). Types of respondents.

1–5 years	20%
6–10 years	11%
11–20 years	10%
20+ years	45%
N/A	14%



(c). Years of experience.

Figure 39: Statistical Descriptive Data from Survey.

5.5 SURVEY RESULTS

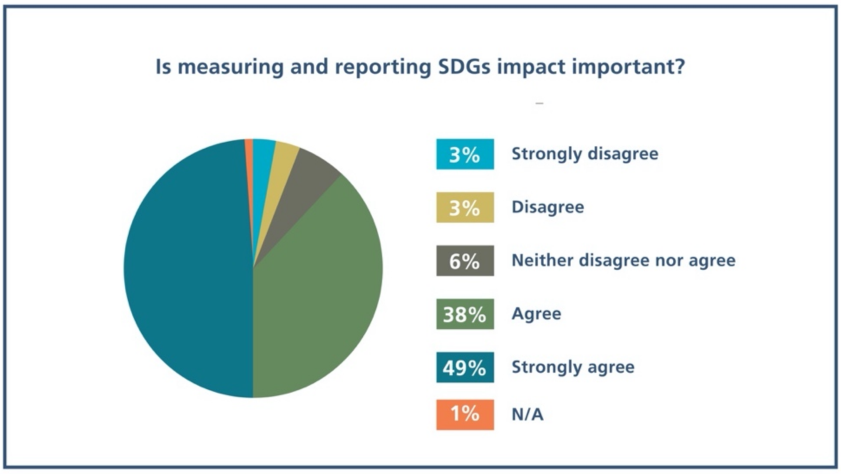
Responses from the survey's primary C-M-O related questions are shown below, with summary data and supporting analysis.

5.5.1 Question 1 (Outcomes): Should engineering businesses seek ways to measure and report SDG impact?

Data overview: The first set of results show that there was overwhelming agreement that it was important that engineering businesses seek ways to measure and report SDG impact. 87% of respondents either agreed or agreed strongly that this was important. Millennials rated this as more important than non-millennials (94% and 82% respectively) (see Figure 40).

Relation to the research question: the data suggests that engineers rate the use of SDG for measuring impact as important and this provides a starting point for delving deeper into the context, mechanism and outcomes issues that affect its application.

Differences analysis: there were few differences, and this strengthened the findings.



	STRONGLY DISAGREE (1)	DISAGREE (2)	NEITHER DISAGREE OR AGREE (3)	AGREE (4)	STRONGLY AGREE (5)	N/A	TOTAL	WEIGHTED AVERAGE
(no label)	3% 5	3% 5	6% 10	38% 60	49% 78	1% 1	159	4.27

BASIC STATISTICS				
Minimum	Maximum	Median	Mean	Standard Deviation
1.00	5.00	4.00	4.27	0.95

Figure 40: Response to Question 1: Should engineering businesses seek ways to measure and report SDG impact?

5.5.2 Question 2 (Outcomes): What are the top 5 SDG goals most relevant to measuring impact of your infrastructure projects and programmes?

Data overview: The survey results showed that engineers have a strong focus on five priority SDGs (shown in Figure 41), namely: SDG6 (clean water and sanitation), SDG7 (affordable and clean energy), SDG9 (industry, innovation, and infrastructure), SD11 (sustainable cities and communities), and SDG13 (climate change).

Relation to the research question: The data suggests that engineers have a priority for measuring 5 SDGs (5,7,9,11 and 13), followed by SDGs 15 and 12. It strengthens the view that MISI is valued by engineers.

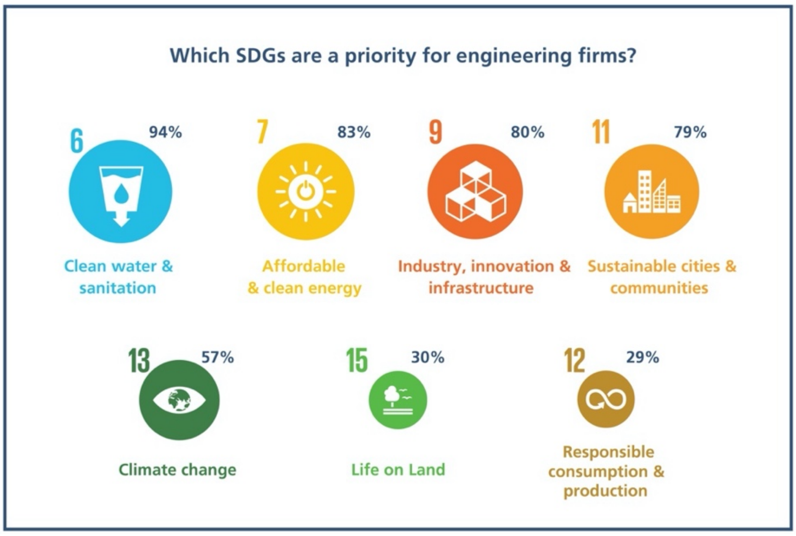


Figure 41: Responses of participants to their five top SDGs that engineering projects should measure impact against – showing the top seven list (with six and seven being significantly less popular).

Differences analysis: The results also showed that there was a marked difference in millennial responses as shown in Figure 42.

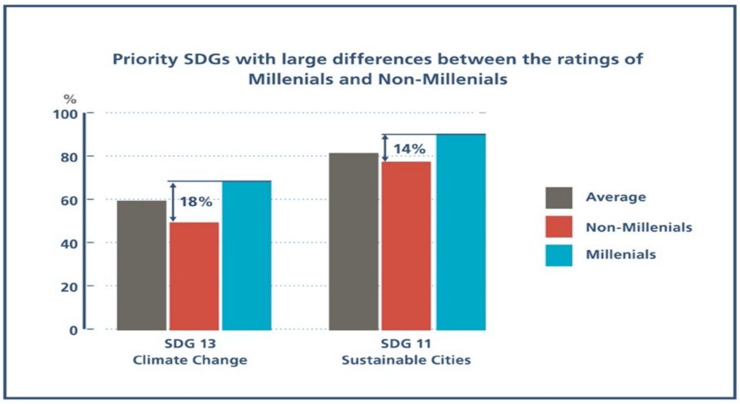
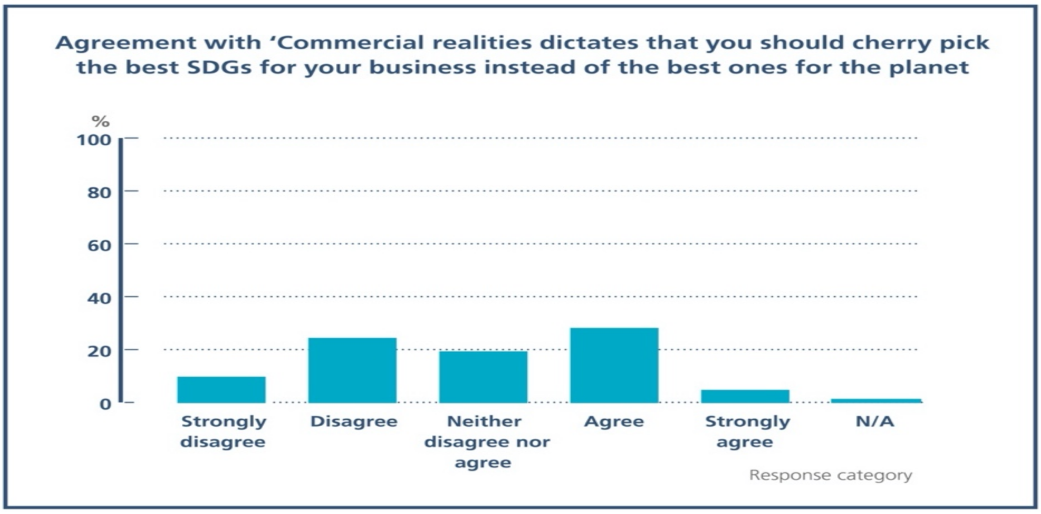


Figure 42: Preference of the SDG 13 and 15; differentiating between millennials.

5.5.3 Question 3 (Mechanism): Do commercial realities dictate the SDGs you pick?

The next question probed the way in which commercial realities influence the selection of SDGs to measure (see Figure 43).



	STRONGLY DISAGREE (1)	DISAGREE (2)	NEITHER DISAGREE OR AGREE (3)	AGREE (4)	STRONGLY AGREE (5)	N/A	TOTAL	WEIGHTED AVERAGE
(no label)	12% 19	26% 41	21% 33	31% 50	9% 15	1% 2	160	3.01

BASIC STATISTICS				
Minimum 1.00	Maximum 5.00	Median 3.00	Mean 3.01	Standard Deviation 1.20

Figure 43. Response to Question 3: Do commercial realities dictate the SDGs you pick?

Data overview: Respondents were nearly equally split on this issue; 36% either disagreed or strongly disagreed that SDG choice was influenced by commercial realities, while 39% agreed or strongly agreed, with 21% non-committal.

Relation to the research question: The responses can be linked to the second question that seeks to identify problem areas. There is evidently an issue that many engineers feel that the businesses they work for can be too commercially orientated. This is not a consistent view, but potentially an area for further exploration.

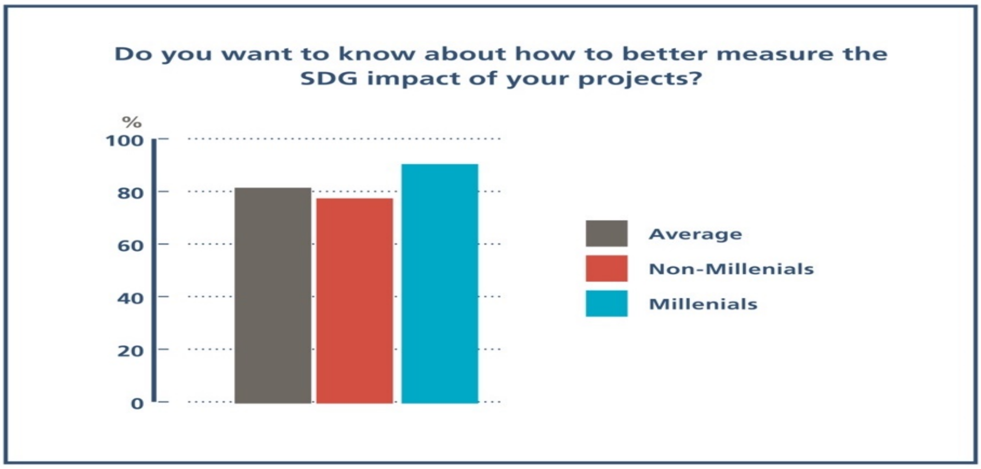
Differences analysis: It is likely that the 'agree' type of responses, as well as the non-committal responses, could reflect the difficulty of interpreting the question. For example, if the respondent identified that the use of SDGs was a secondary consideration after ensuring 'business survival' they might have agreed with the proposition, whereas an alternative position might have been to suggest SDGs are good for business based on the wider 'societal shared values'.

5.5.4 Question 4 (Mechanism): Do you want to know more about measuring SDG impact on your projects?

Data overview: In addition, the overwhelming majority of engineers wanted to know more about how to measure SDG impact on their projects better (83% vs. 17%), especially among the millennial generation (see Figure 44).

Relation to the research question: this supports the rationale for deepening the research and provides a useful way to seek interviews with CEOs in the follow-on stage of this research programme.

Difference analysis: there were few differences which strengthened the findings and provided evidence to further evaluation into this area in future research.



ANSWER CHOICES	RESPONSES	
Yes (1)	83%	181
No (2)	17%	37
TOTAL		218

BASIC STATISTICS				
Minimum	Maximum	Median	Mean	Standard Deviation
1.00	2.00	1.00	1.17	0.38

Figure 44. Response to Question 4: Do you want to know more about measuring SDG impact on your projects?

Data overview: 87% of respondents either agreed or agreed strongly that this was important. Again, millennials rated this more importantly, at 94% versus 82% for non–millennials (see Figure 44).

Relation to the research question: The survey respondents gave very strong support to the view that it was important that engineering businesses seek ways to measure and report SDG impact. This consolidated the views expressed in earlier questions that this was a matter of import and that they wanted to be engaged in future knowledge and learning activities. The responses would help galvanise future engagement in this research project.

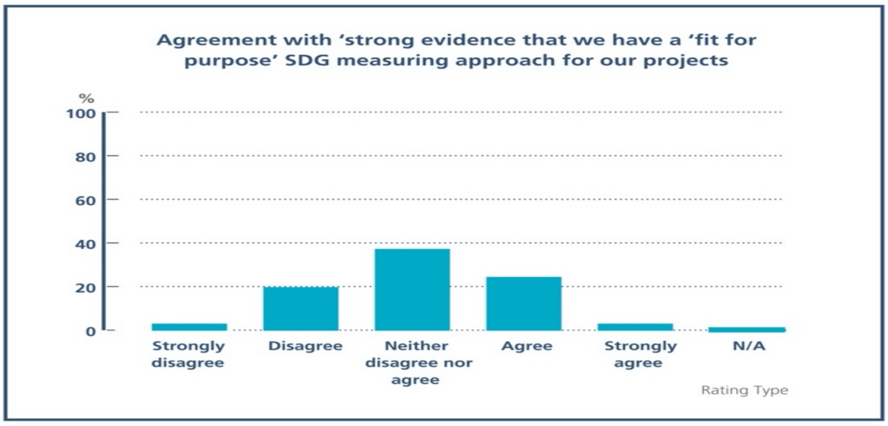
Difference analysis: millennials were stronger in their responses but not at a significant level.

5.5.5 Question 5 (Mechanism): What is the engineers' view on current infrastructure projects and their achievement of the SDGs?

Data overview: Only 34% of engineers believed that 'there is strong evidence that we have a 'fit for purpose' SDG measuring approach to track our projects' impact on SDGs. 37% neither disagreed nor agreed, probably due to the fact that it is such a complex and difficult challenge to measure impact and to-date, the industry continues to struggle to find a practical and workable solution to this issue (Merry, 2019; Fukunda-Parr and McNeill, 2019).

Relation to the research question: The results reveal some areas where the current measurement of projects' SDG impact needs improvement (see Figure 45). Despite the strong support for the importance of measuring and reporting SDG impact, and the clear identification of five priority SDGs for the sector.

Difference analysis: there were significant differences but across a balanced response curve. This could be interpreted positively (only 24% did not agree) or negatively (only 34% agreed).



	STRONGLY DISAGREE (1)	DISAGREE (2)	NEITHER DISAGREE OR AGREE (3)	AGREE (4)	STRONGLY AGREE (5)	N/A	TOTAL	WEIGHTED AVERAGE
(no label)	5% 8	19% 31	37% 59	27% 43	7% 12	5% 8	161	3.13

BASIC STATISTICS

Minimum	Maximum	Median	Mean	Standard Deviation
1.00	5.00	3.00	3.13	0.99

Figure 45. Response to Question 5: Do we have a 'fit for purpose' measuring approach to track projects' SDG impact?

5.5.6 Question 6 (Context): What are the greatest challenges for measuring SDG impact?

Data overview: The respondents to the exploratory survey said that the four greatest challenges were (see Figure 46): success definition (56%), business priorities (55%), leadership (52%), and a focus on outputs rather than outcomes (46%).

Relation to the research question: these responses address the aim to identify contextual issues with strong linkage to the study's C-M-O 'Variables Framework'. This starts to build a nodal framework for further investigation in the interview stage and also provides links to the 'outcomes' issues.

Difference analysis: the four issues with the highest incidence are all within 42-58%. Each of the margins between the issues is 4-6%, which shows a balanced and consistent view without outliers.

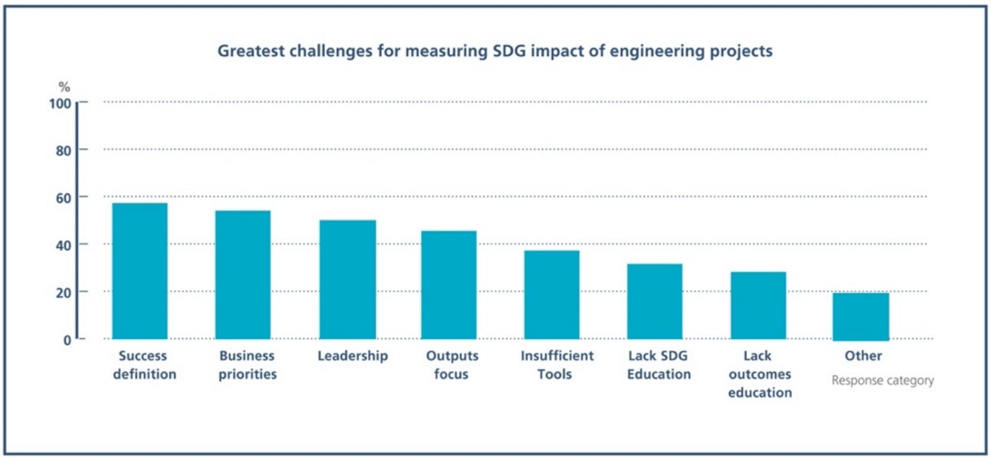


Figure 46. Responses to Question 6: What are the greatest challenges for measuring SDG impact?

The four top challenges identified in the results can also be interpreted as reflecting the difficulties of integrating business needs with the SDGs in the absence of shared value business strategies, although 'success definition' could also reflect the lack of KPIs to measure SDG performance on engineering projects.

5.5.7 Question 7 (Context): How could the achievement of the SDGs on future infrastructure projects be improved?

Data overview: This exploratory research shows that in terms of the greatest opportunities within engineering firms, the top four opportunities were leadership

(57%), increased education and training in SDG impact skills (57%), use of a simple and widely used tool (55%), and business skills (48%).

Relation to the research question: The penultimate set of results reveals some initial views about how the performance of future projects against SDG targets can be improved (see Figure 47 below). This responds to elements of the research question (2 and 2.1-2.3) and highlights consistency with the earlier question shown in the previous paragraph. Notable alignment is in three areas: leadership; business understanding of success; and further investment in education.

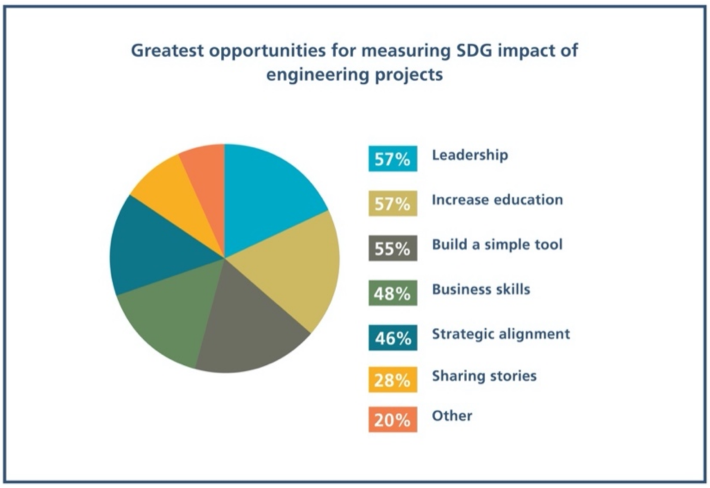


Figure 47. Responses to Question 7: What are the greatest opportunities for measuring SDG impact?

The challenges were also compared to the 'opportunities' in Figure 48 to assess the respondent's understanding of whether the same themes were noted as both a challenge and an opportunity. There were data linkages between the two results, with 'leadership' and 'business skills/success definition' appearing in both of the top four responses.

From Survey: Challenges/opportunities to measuring the projects' SDG impact:

Challenges:
1. Success definition (56%),
2. Business priorities (55%),
3. Leadership (52%)
4. Focus on outputs rather than outcomes (46%)

ANSWER CHOICES	RESPONSES	
Success definition. Inconsistent definition of what defines projects' success - eg more than time, cost, scope? (1)	57%	92
Outputs/outcomes. Too much focus on outputs and not enough on outcomes and wider benefits? (2)	46%	74
Tools. Insufficient credible quantifiable measures linking project success to SDG impact? (3)	39%	62
Education. Insufficient understanding of credible quantifiable measures for reporting SDG impact? (4)	32%	52
Education. Under-investment in skills and capabilities education to support definition of outcomes? (5)	29%	47
Leadership. Without sufficient leadership to drive focus on the SDGs. (6)	52%	83
Business Priorities. That business priorities get in the way of seeking SDG outcomes. (7)	55%	89
Other (please specify) (8)	18%	29
Total Respondents: 161		

BASIC STATISTICS

Minimum	Maximum	Median	Mean	Standard Deviation
1.00	8.00	4.00	4.21	2.31

Opportunities
1. Leadership (57%)
2. Increase education and training in SDG impact skills (57%),
3. Build a simple tool (55%)
4. Business skills (48%).

ANSWER CHOICES	RESPONSES	
Strategic alignment. Using the GEC opportunity to build alignment on how our community demonstrates impact. (1)	46%	73
Sharing stories. Use video platforms and Apps to enable rapid sharing of SDG impact stories. (2)	36%	57
Build a simple Tool. Develop a credible quantifiable measurement linking project success to SDG impact. (3)	55%	88
Education. Increase training and education as a student and as Career Professional Development in SDG Impact skills. (4)	57%	91
Business Skills. Investment in developing business skills that reflects commercial realities and the SDG Impact? (5)	48%	77
Leadership. Leadership increases drive and support for demonstrating SDG impact. (6)	57%	90
Other (please specify) (7)	16%	26
Total Respondents: 159		

BASIC STATISTICS

Minimum	Maximum	Median	Mean	Standard Deviation
1.00	7.00	4.00	3.83	1.80

Figure 48. Responses to Question 6 (opportunities) and 7 (challenges) for measuring SDG impact? (See Appendix 5 for full data)

5.6 INFERENTIAL STATISTICS

Chi-Square analysis provided a p-value of between 0.001 and 0.132 (see Appendix 5). Therefore, the statistical validation was not found to be consistent and as such the findings should be viewed as an indicator of where further research can be focused. However, the survey, even without feedback from the 40 interviews with CEOs and Heads of Sustainability (discussed in the next chapter), has provided increased confidence that there is a gap between current practices and engineers' strong desire to improve how sustainability is addressed in the context of infrastructure projects.

5.7 DISCUSSION OF SURVEY RESULTS AND DEVELOPMENT OF THEORETICAL FRAMEWORK

The survey captured engineers' views on the measurement of SDG impact on projects. Therefore, it provided an individualistic and rich perspective on the views of engineers on the importance of SDG measurement. The survey also specifically examined the mechanism and context of SDG measurement to identify strengths and weaknesses of employing such an approach. In doing so, the survey identified that the overwhelming majority (87%) of engineers surveyed have a strong appetite for action on the SDGs. From the engineers surveyed, millennial engineers are 15-20% more likely than non-millennials to want to work on projects that deliver according to the SDGs. However, this strong focus and desire, almost commitment, to the SDGs and their materialisation was accompanied by an equally strong frustration with the lack of solutions that are fit for purpose and currently available for use in industry.

5.7.1 Analysis of Results and Further Development of the Research Model

The survey highlighted four **findings** to improve the effectiveness of SDG measurement at the sub-national levels: (1) tools and methods, (2) suitable training geared towards an understanding of the SDGs, (3) definition of business success that differentiates between outputs and outcomes, and finally, (4) the most frequently identified success factor was the leadership and governance tailored to driving change under the SDG framework. This led to eight core themes that emerged from the results, which are discussed within the three categories of Context, Mechanism and Outcomes, consistent with the C–M–O Realist Evaluation approach (Zachariadis et al., 2013). The first category of *Context* had four emergent themes: leadership & governance (C1); business skills for engineers (C2); performance measurement tools (C3); and, millennials (C4). The second category of *Mechanism* had three emergent themes: Prioritisation of SDGs (M1); Adapting to Levels of P3M Complexity (M2). The third category was *Outcomes*, which had two themes: outputs versus outcomes as definition of project success (O1); and, adopting a Creating Shared Value approach using the Theory of Change and the Triple Bottom Line (O2).

5.7.2 Context

5.7.2.1 Leadership—Governance (C1)

Unsurprisingly, leadership was identified as a dominant contextual issue in the measurement of SDG impacts at organisational and project levels. Whilst the results from the engineers' survey are insightful, the data needed triangulation by seeking the senior leaders' attitudes in the follow-on interview stage of this research. This captured views of 40 CEOs and senior executives to gain an organisational perspective on the dominant contextual issues. It was expected that leadership would be a prominent theme because of its role in transformation, which lies at the core of adopting the SDG lens to measure business and project success.

As Metcalf and Benn noted (2013), leadership is a well-recognised success factor in the implementation of sustainability and CSR in businesses. The SDGs have similar complexity patterns to sustainability, with an equal need for adaptive systems that place an extraordinary demand on leaders (Metcalf and Benn, 2013). These leaders need the skill sets that can balance the complexities of achieving the economic business success of profitability with the increasing demands on co-balancing with environmental and social objectives. The visionary leaders will be the ones that harness the CSV mindset and then can empower and align their organisations with the people, profit and planet thematics of TBL, thinking and acting within 'systems of systems' models that seek innovative solutions to the SDG challenges (Fullan 2005).

5.7.2.2 Business Skills for Engineers (C2)

Following on from the previous theme of defining success through outcomes and not just through the traditional outputs of time, cost and scope (and quality), the survey results also indicated the need to build capability and capacity amongst engineers. This complements the work by Zahra et al. (2006) into entrepreneurship and dynamic capabilities needed of engineers beyond their traditional technical expertise. Others (Armanios et al., 2017) proposed that the broadening of skill sets to include business skills of innovation and definition of broader TBL success will play a more dominant part of the education and learning syllabus in future. In this regard, it was suggested by a number of respondents that embedding business skills learning within core engineering educational programmes would help provide opportunities for meaningful improvements in the measurement of SDG performance on projects.

5.7.2.3 Measurement Tools and Processes (Methodologies) (C3)

There are many authors that recognise the need for using benefits and impact performance measurement to ensure strategic plans are delivered effectively and efficiently (Micheli and Manzoni, 2010; Prasad et al., 2003). The survey responses also showed that there is significant room for improvement on availability of 'fit for purpose' engineering tools and methodologies to measure SDGs. These results highlight the need for a new simple tool (such as a set of KPIs linked to the SDG indicators) developed with a global sustainability body, such as the Global Reporting

Initiative (GRI). This might allow the engineering community to align projects' SDG reporting with the growing trend of using global standards to report sustainability, with 93% of the world's largest 250 corporations reporting on their sustainability performance in 2018 and 82% (Global Reporting Initiative, 2016) of these using GRI Sustainability Reporting Guidelines to do so.

5.7.2.4 Millennials (C4)

In addressing the research question on engineers' use and rating of SDG measurement at local levels, a further investigation was carried out to explore potential differences between millennials and others. In a highly encouraging note, the survey results indicated that millennial engineers are 15–20% more likely than non-millennials to want to work on projects that deliver the SDGs. This is a key insight for engineering business leaders to take note of (such as CEOs and other managers) because in the UK alone, 50,000 engineers (all forms) will have to be recruited per year until 2022 to meet the projected level of demand for qualified engineers (ICE, 2018). These talent management priorities will be important to business resilience in the near future. Indeed, the identified lack of alignment between millennials' perceptions of businesses' motivations balanced against their own imperatives is typically shown in their allegiance to employers (Deloitte, 2018b). Simply stated, if businesses do not make a greater effort to demonstrate their ability to create shared value that achieves financial, but also environmental and social, outcomes, then it will not engender loyalty. In turn, this may result in higher staff turnover, thereby damaging its business interests as well as negatively impacting the projects' delivery of SDGs.

The survey results are further evidenced by a report from Deloitte (2018a) on findings from over 10,000 millennials. The Deloitte (2018b) survey indicated a distinct, negative shift in millennials' attitudes on CEO's and business' motivations and ethics. Today, less than half of millennials believe businesses operate ethically (48% balanced against 65% in 2017) as well as a drop in the number of them that believe that CEOs are committed to supporting society (47% balanced against 62% in 2017). This highlights that there is a significant mismatch between what millennials define as responsible organisations and the people that lead them, in terms of what responsible businesses should aspire to achieve. The message is clear that millennials want business leaders to be proactive about making a positive impact on society. Measuring projects' SDG impact is a way to do this.

5.7.3 Mechanism

5.7.3.1 Prioritisation of SDGs (M1)

The survey highlighted a clear preference for measuring just five SDG goals (there was a 50% reduction in the preferences for the next two SDG goals). This indicated a long tail of ten further goals that did not appear to resonate with participants. The literature review also noted that there is a growing body of evidence (Allen et al., 2019; Bali Swain and Yang-Wallentin, 2020; Jones and Comfort, 2020) that suggests that the complexity of the 17 Goals and the 169 targets needs to be simplified and a reduced selection prioritised for measurement. Combined, the findings from the survey on the top five SDGs and the complexity noted in the literature review is consistent with the advice given by the UN Global Compact in their proposed methodology (GRI, 2015). This indicated an important area for further research to assess how this simplification can be achieved at organisational and project levels.

5.7.3.2 Organisational, Portfolio, Programme and Project (P3M) Complexity (M2)

The survey questions did not specifically address the separate levels of organisations and projects, which in the project management discipline, is referred to as portfolio–programme–project management (P3M) levels. This becomes important in the development of a prototype since the measurement of SDGs at the enterprise level (the portfolio) will likely be different from that at programme and project levels. This required further exploration in the interview stage (next chapter). The non-response error highlighted that the survey of organisational level had not achieved its objectives and that this should be addressed in the next research stage of the forty interviews, which introduced the wider issues of the Muller OPM (2019) structure.

5.7.4 Outcomes

5.7.4.1 Defining Success—Outputs Versus Outcome (O1)

The survey showed that engineers agreed that too often, projects define success by traditional outputs using the so-called 'iron triangle' of time/cost/scope (and quality) dimensions to deliver on the SDG goals. Instead, the majority of survey respondents agreed that the engineering and project management communities need to place a greater emphasis on the achievement of long-term outcomes and a corresponding broader definition of success.

5.7.4.2 Creating Shared Value using Theory of Change and Triple Bottom Line (O2)

As noted above (Section 5.4.1), the survey showed that many engineers agreed that the choice of SDG goals and targets should be primarily selected on the basis of business profitability. This is counter to CSV and TBL. As a result, the longer-term value of making investment decisions based on broader TBL principles could be weakened. Therefore the next research stage, to inform the development of the prototype, investigated how the TBL could be integrated with the measurement of SDGs.

5.8 DEVELOPMENT OF CONCEPTUAL FRAMEWORK FOR MEASURING THE SDG PERFORMANCE OF INFRASTRUCTURE PROJECTS

The identification of the four context issues discussed above offers insights into the situational effects on the likely success of the mechanism. Stated slightly differently, for the measurement of SDG impacts to deliver the outcomes expected, the contextual situation needs to be appropriate. For example, without the requisite organisational leadership inter- and intra-businesses, from the government as well as executives, the measurement of SDGs will not be successful. This survey therefore informed the next stage of the Sequential Explanatory Design (Creswell and Creswell, 2017) that involved interviews of forty senior executives. It was proposed to deepen the exploration of the four context issues by using a nodal coding system (Creswell and Creswell, 2017) for the interviews. This strengthened the analysis and, combined with the literature review to enable the triangulation of data, enabled the development of a robust prototype to test the approach with practitioners.

Four of the mechanism and outcome C–M–O themes, noted in Sections 5.3 and 5.4, are further explored below in Table 12 to identify themes that could be included in the next study stage. As a deduction, it was posited that the shared value approach aligns individual business priorities of specific firms with sustainable development imperatives. Consequently, adopting an enhanced SDG measurement approach is capable of releasing the energies of businesses to pursue competitive advantage and the SDGs through integrated business strategies.

As a way of summarising the conceptual development of a prototype SDG measurement model (started in Chapter 3, but further refined in Chapter 7), based on the literature review and survey findings presented in this study, a tabulated compendium is shown below that includes some exploratory questions, with derived findings and supporting literature. This has been used to shape the design of the interview questions, shown later in Chapter 6, Figure 51.

Table 12: Summary of conceptual development of a future prototype model for SDG measurement, based on the survey results in this study.

C–M–O Future Research Focus	Findings Derived from Stage 1 Research to inform Prototype development	Supporting evidence from the Literature Review
Prioritisation of SDGs (M1)	1. Only a small proportion of the 1554 SDG indicators are currently being measured at the project level, and consequently, there is a large gap between global definitions of SDG objectives and project-level definitions of action. 2. The evidence of the difficulty to use the existing 169 targets and 232 indicators suggests that the derived model should recognise that a contextual perspective needs to be adopted to keep it simple for practitioners who are already heavily committed to other performance measurement frameworks.	Klopp and Petretta 2017; Donohue et al. 2016; Nerini et al. 2018; Allen et al. 2016; IPCC 2018; Swain 2018; UN 2018; Hall et al. 2016; Martens and Carvalho 2016a, 2016b
Organisational P3M Complexity and Sustainability (M2)	1. Measurement of SDG performance should accommodate the required different organisational levels, namely portfolio, programme and project levels. 2. That existing sustainability measurement at organisational and project levels is well established, and therefore, SDG measurement should be aligned to existing successful approaches, not created as an 'add-on' (i.e., the organisational level will likely have different SDG imperatives and reporting requirements, such as using the GRI, from the project level, which might have limited capability and capacity to track too many targets and indicators.)	Morris 2013; Cooke-Davies 2007; Morris 2017; NAO Report Projects (National Audit Office 2005); Silvius and Schipper 2014; Silvius et al. 2017; Martens and Carvalho 2016; Økland 2015; Silvius and Schipper 2014; APM 2019; Sawaf and Gabrielle 2014; Bonini and Emerson (2005); Bugg-Levine and Emerson 2011; Preston 2012; Malhi et al. 2009; Suess 1980; Tilt 2009; Perrini and Tencati 2006; Kaplan and Norton 1996
Defining Success—Outputs	1. Measurement of SDG performance should be viewed from a systemic perspective and thereby move beyond the traditional 'iron	**Theory of Change and Logic Model**: Stein and

Versus Outcome (O1)	triangle' view of projects in the short term (i.e., according to schedule, budget, scope and quality performance) and additionally, take account of longer-term project outcomes and impacts. 2. The model should harness the core concepts of the Theory of Change and the Logic Model, with their focus on outcomes measurement, including the analysis of causal linkages, engagement of stakeholders and strategic design with the 'ends' being the starting point for a right to left causal mapping.	Valters 2012; Weiss 1995; **Project Success**: Thiry 2004; Themistocleous and Wearne 2000
Creating Shared Value using Triple Bottom Line (O2)	1. Measurement of SDG performance should accommodate the perspective of Creating Shared Value (CSV) (i.e., seeking solutions that are good for business in the short and longer term through balance of profit–planet–people objectives). 2. Measurement of SDG performance should accommodate the perspective of the Triple Bottom Line (i.e., social, environmental and economic performance). This will drive a broader definition of project sustainability that includes the three pillars (i.e., social, environmental and economic performance). It provides simplicity and structure for the analysis in regard to selecting and measuring SDGs.	**Creating Shared Value**: Porter and Kramer 2011; Elkington 1994, 2018; OECD 2019; UN 2018; **Triple Bottom Line**: Elkington 1994, 2018, 2018; Griggs et al. 2013

5.9 LIMITATIONS OF SURVEY

A potential limitation of the study may have emerged as originally the survey was intended to capture attitudes of both individual engineers as well as organisations. However, this was not successful because respondents were unable (with only five exceptions) to provide an authoritative organisational perspective. This was a form of non-response error (Singleton and Straits 2010), and the strategy to reduce this error was to firstly diagnose the problem and then find ways to mitigate the error. The reasons given when the researcher followed up with a few known participants who had waivered their anonymity and volunteered their feedback was that no official statement would be given by large organisations on a survey without having secured senior leadership sanction. These organisations were later approached at the interview stage of the research study, which involved CEOs and Heads of Sustainability who had the authority to provide a corporate statement on their organisations' SDG measurement strategy.

A further limitation might be considered that a full pilot was not included prior to the full go-live of the on-line survey. This might have mitigated the 'non-response' limitation described above. In actuality, the 'Step 5 Specify and test survey Procedure', detailed in Table 11, included the plan to build the logic framework in the chosen survey tool and once completed, to run 'check tests' with informed analysts to ensure the technical success and the logic of the procedure. This allowed the full process of the respondent interface to be checked. Whilst, this preliminary procedure was completed, the subsequent problem with the lack of organisations responding was not identified and provided a useful learning for the researcher.

Singleton and Straits (2010) highlight the need for self-awareness of bias when using surveys and actively address these from the start. As an example, as shown in Table 11, the survey approach addressed four known biases: (1) asking the wrong question, which was addressed by testing the questions in a pilot stage and getting feedback and adapting where necessary; (2) surveying an inadequate sample, which was addressed by partnering with the ICE to benefit from a defined group of engineers (they were all active members of a global standards body), although 'opting-in' meant that the sample was potentially biased in favour of the survey due to participants being more aware of sustainable development; (3) the single nature of the survey format did not allow for a free-flowing of ideas, and the time restraint of making it relevant and accessible to busy professionals to be part of the survey meant it lacked the depth of separate interviews. This was balanced by having a follow-on phase of 40 interviews with construction company CEOs; (4) misrepresenting the data results, which was addressed by having forums hosted at the ICE to share back the findings in discussions (as described in Stage 4 of the Analysis phase in Table 11). This feedback was used to shape the design requirements of the follow-on interviews.

The resultant view against the C-M-O framework after the survey is shown below in Figure 49, as an illustrative subjective analysis based on the researcher's interpretation of the survey's quantitative results. The qualitative maturity of the C-M-O evidence is shown by using 'Harvey Balls' to aid visual communication of qualitative information. They are commonly used in comparison tables to indicate the degree to which a particular item meets a particular criterion, and users of them, such as Groenland (2016) suggest that they discourage readers of a report from '*attributing quantitative meanings to qualitative data*'.

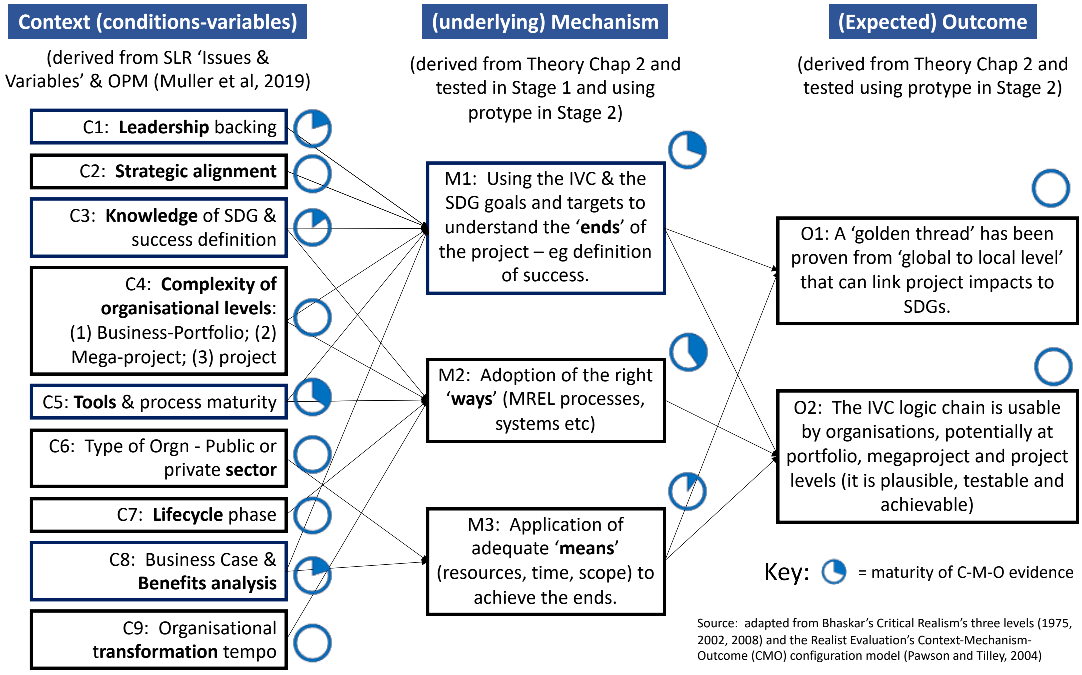


Figure 49. View 1 – Maturity of C-M-O evidence across variables and study areas.

5.10 CONCLUSIONS AND INPUT TO NEXT STAGE OF STUDY

This chapter started from the premise that there is a problem with linking the SDG global-level goals to the local-level delivery on infrastructure projects. This potentially manifests in poorer investment decisions on infrastructure projects because they are too often based on purely financial return on investment (RoI) instead of a broader set of criteria across the TBL of economic, environment and society. In order to explore the identified gap in the literature, the study adopted a mixed-method approach of a Sequential Explanatory Design (Creswell and Creswell, 2017). This addresses the first stage, a survey of 325 engineers, to answer the research question of 'How do engineers in the construction sector rate and use global UN SDG goals for infrastructure investment decisions at local level? To derive the answer, it used the Realist Evaluation methodology of the Context–Mechanism–Outcomes model (Pawson and Tilley, 1997) to structure and evaluate practitioners' views on using SDGs to measure local success.

Despite limitation of the sample (all 325 ICE members 'opted-in', inferring interest), the results of the survey show that the vast majority (87%) of engineers surveyed have a strong appetite for action on the SDGs. From the engineers surveyed, millennial engineers are 15–20% more likely than non-millennials to want to work on projects that deliver the SDGs. However, this strong focus and desire, almost commitment, to the SDGs and their materialisation was accompanied by a strong frustration with the lack of solutions that are fit for purpose. This stage of the research identified that there is a gap between their perceived importance of measuring SDG impact, contrasted with their current capabilities (such as skills, knowledge, leadership, tools and approaches) to do so.

The limitations of this exploratory research are that it has not provided definitive findings from the perspective of organisations. However, it helped to narrow the scope of future research by establishing priorities for the next stage and a signpost for further analysis that deepens the research. Through use of the refined research framework developed from this survey, with key assumptions and derived research questions, there was an opportunity to deepen understanding of this important area in the interview stage. This guided the next stage of the forty interviews of engineering organisations' CEOs and Heads of Sustainability, discussed in the next chapter.

The building of the evidence to respond to the study's propositions is shown below:

Table 13: Development (2nd) stability of Proposition Results (changes since previous Chap in red)

Confidence in Evidence for Propositions	P1: Engineer's view of current MISI	P2: Organisational view of MISI	P3: 'Golden Thread' global - to - local	P4: Prototype Development
Theoretical Analysis	Not yet	Not yet	Very Low	Very Low
Survey Analysis	Moderate	Very Low	Very Low	Very Low
Interviews Analysis	Not yet	Not yet	Not yet	Not yet
Test 1: Golden Thread	Not yet	Not yet	Not yet	Not yet
Test 2: Case Study	Not yet	Not yet	Not yet	Not yet

(Note 1: The assessment of the quality of propositions' evidence is based on a qualitative formula designed by the Clinical Grading Working Group's British Medical Journal's study (GRADE, 2004). Full description in shown in Table 8.)

Chapter 6: Interview Method, Results and Analysis

6.1 OUTLINE OF CHAPTER

This chapter describes the design adopted for the interviews to achieve the aims and objectives stated at the end of Chapter 1. Section 6.2 discusses the methodology used for this second part of the Sequential Explanatory Design (Creswell, 2017), the interviews of 40 CEOs and Heads of Sustainability, the stages by which the methodology was implemented, and the research design; section 6.3 details the data analysis methodology, followed by section 6.4 that provides more detailed description of the interview analysis process. Verification is discussed in Sect 6.5, with the results and discussion included in Sections 6.6 and 6.7, with the conclusions in Section 6.8.

6.2 METHODOLOGY AND RESEARCH DESIGN

6.2.1 Methodology

The broader research design, outlined in Chapter 4, involved a three-way data collection approach (Figure 37). At its core, the research design built on the triangulation of qualitative and quantitative datasets, which is well recognised as a method for informing theory-led research development (Creswell, 2017; Easterby-Smith et al., 2002). In what Creswell (2017) describes as a Sequential Explanatory Design, the literature review informed the survey questions and analysis that has informed the structure and approach of the interviews discussed in this chapter. In this way Merriam and Grenier (2019) suggest that ‘the interviews help the researcher understand the responses to the survey (Mansell et al., 2020) as well as provide additional insights into the phenomenon of interest’.

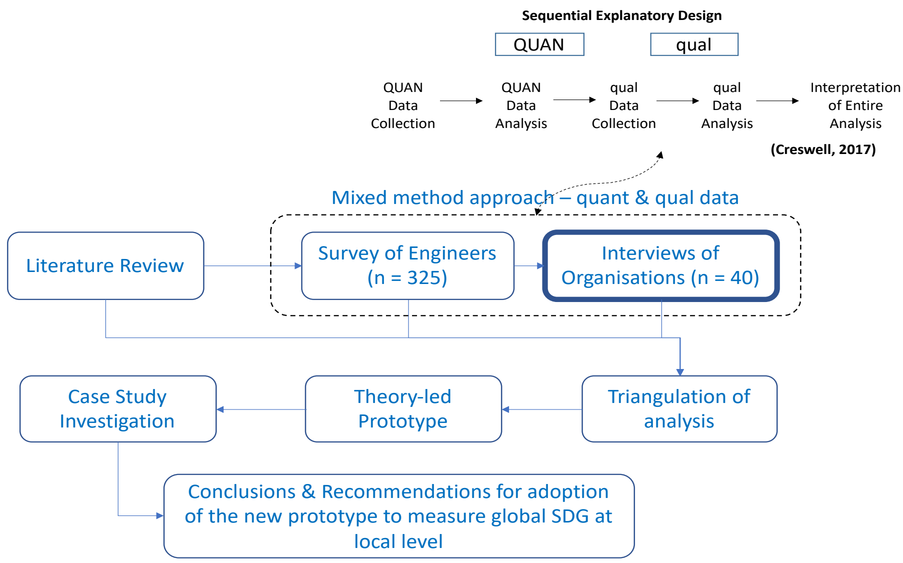


Figure 50: The research design of mixed method Sequential Explanatory Design, adapted from Creswell (2003 and 2017).

As shown in Figure 50, the development of a prototype SDG measurement model was to be based on the triangulation of learning from the literature review, the survey of 325 engineers and the subsequent interviews of 40 senior executives.

This chapter discusses the interview stage in-depth. A primary advantage of the semi-structured interview method is that it allows an adaptive-responsive approach to ensure the best improvisation to delve deeper into relative areas of importance, based on the Participant´s responses (Hardon et al. 2004, Rubin & Rubin 2005, Polit & Beck 2010) and it also allows for participants' verbal expressions to be captured (Robert Wood Johnson Foundation, 2008).

6.2.2 Interview Question Design

The semi-structured interviews were designed to explore attitudes in relation to the research question and its subsidiary three sub-questions (shown in Figure 51). The sub questions focused on three areas: the perceived value and importance of measuring SDGs (i.e. the outcomes); their current approach and capability (i.e. the mechanism); and, their identification of the challenges and opportunities (i.e. the context) such as skills, tools, processes, structures and methods (Astbury and Leeuw, 2010: 386). NVivo© was chosen as the web-enabled data collection tool. The selected organisations all 'opted-in' to the interview process and given the seniority of the participants, they had a very strong understanding of their company's strategic vision and the marketplace that they operate in which strengthened their ability to comment on the value of SDG measurement. They were all prominent in their field and as a result of agreeing to be interviewed, would have ensured that they understood the nature of SDGs and their relevance to their business. For example, the CEO of a transport mega project admitted that his company had not actively used SDG for measuring success, but that the request for an interview had piqued his interest and as a result he was very interested in finding out what others in his sector were doing in this area.

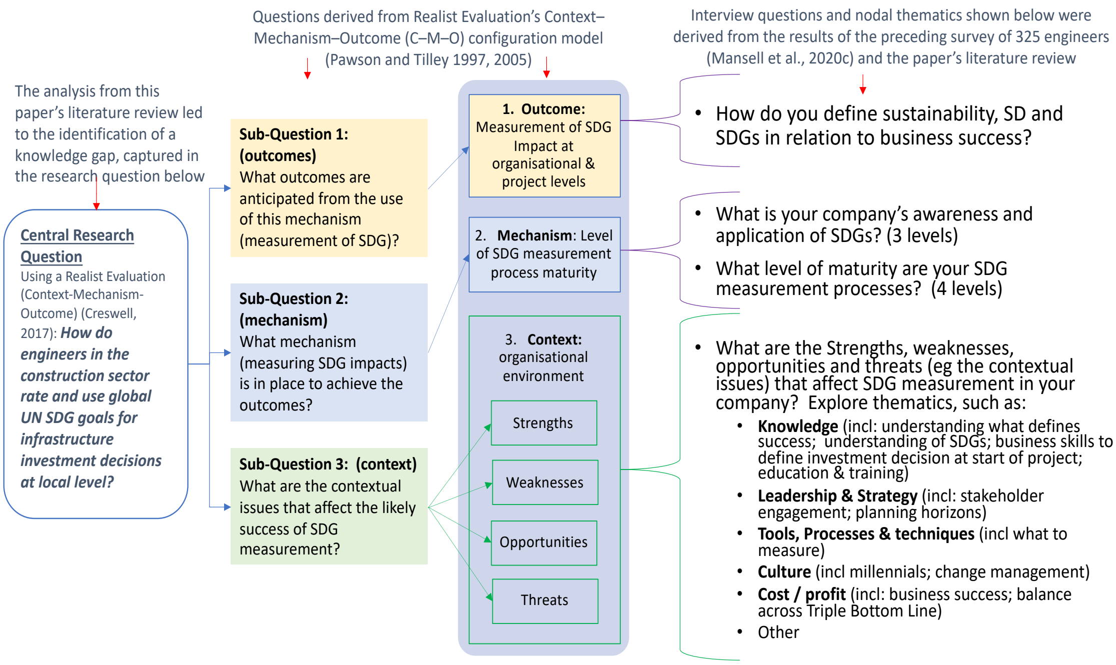


Figure 51. The nodal evaluation framework for sequential explanatory design from which the semi-structured interview questions were derived.

6.2.3 Derivation of the Questions

The questions that are shown in Figure 51 were derived from a variety of sources, both inductively and deductively. The central research question was informed by the literature review, which highlighted a knowledge gap. The importance of understanding why the gap existed and how to close the gap had also been identified in the survey of 325 engineers (discussed in the previous chapter), in which 88% of responses affirmed that stakeholders wanted to increase their ability to measure SDGs on projects. This was strengthened by a response rate of only 34% stating that they had a "fit-for-purpose" mechanism to measure the SDG impacts (Mansell et al., 2020c). The sub-questions 1–3 shown in Figure 51 were derived from the adoption of the realist evaluation's context–mechanism–outcome (C–M–O) configuration (Pawson and Tilley, 1997), which is widely used across clinical research (Pawson et al., 2005) and increasingly also across the social sciences (Linsley et al., 2015). As stated earlier, Pawson and Tilley specifically recommend the C–M–O strategy so that "programme theories can be tested for the purposes of refining them" (2005, p. 2). The third level of questions for the interviews (shown in the right column in Figure 51) combines the Pawson and Tilley C–M–O framework (1997, 2005) with the survey results (Mansell et al., 2020c). For example, the four contextual questions that were derived from the SWOT (strength, weakness, opportunity and threat) analysis approach discussed earlier, were all topical responses from the surveys that engineers had identified as either "blockers" or opportunities (Mansell et al., 2020c).

6.2.4 Access

The interviews aimed to gain access to 40 CEOs or heads of sustainability. Given the GDPR issues around accessing the names of the senior executives of global companies, the research partnered with the Institution of Civil Engineers (ICE). The ICE vetted the research scope and agreed to provide the personal data on the basis of the work aligning with GDPR legalities. The author contacted a total of 85 organisations at the level of CEO and heads of sustainability, of which 40 agreed to be interviewed.

6.2.5 Sample Size

As mentioned above, sampling was achieved purposefully by partnering with UK's leading construction standards body, the Institution of Civil Engineers (ICE), to identify and select leaders in construction companies who had demonstrated a willingness to be involved in innovative knowledge development. All the interviewees had significant knowledge of the infrastructure sector, but a few (*ca*. 5-6) did not have the same detailed knowledge of how their organisations proactively engaged with the UN SDGs. The reason for some having lower knowledge of the SDGs was that their SDG strategies and approaches were at an embryonic stage. But most were actively involved, at the Board-Executive level, in the SDG agenda of their organisation and were rallying stakeholder commitment in this regard. Given the few that had less knowledge, the sample included 30% (12 of the 40) Heads of Sustainability, who had the requisite detailed knowledge of measurement methodologies and approaches.

6.3 DATA ANALYSIS

6.3.1 Descriptive Statistics

The 40 interviews were conducted between July and September 2018, although two of the interviews had to be cancelled and the participants submitted their answers in writing. The sample profile is shown in Table 14.

Table 14: Profiles of participants.

Participant ID	Role in Company	Size of Company (number of employees)	Geography of Business	Length of Interview
1	Board	Other	Other	45
2	Senior executive	10–25k	Global	55
3	Head of sustainability	25–50k	Global	61
4	CEO	1–5k	Regional	42
5	CEO	1–5k	Regional	53
6	Senior executive	1–5k	Regional	53
7	CEO	>50k	Global	40
8	CEO	1–5k	National	42
9	Head of sustainability	1–5k	National	36
10	Senior government or UN policy director	1–5k	National	52
11	Senior executive	1–5k	National	36
12	CEO	5–10k	National	35
13	Senior executive	<1k	National	42
14	CEO	<1k	National	52
15	Head of sustainability	5–10k	Global	56
16	Board	5–10k	Global	56
17	Senior executive	>50k	Global	21
18	Senior government or UN policy director	Other	Other	36
19	Head of sustainability	10–25k	Global	75
20	Head of sustainability	10–25k	Global	55
21	Board	5–10k	Regional	45
22	Head of sustainability	1–5k	Regional	45
23	Head of sustainability	10–25k	Global	45
24	Senior executive	1–5k	Global	39
25	Senior executive	10–25k	National	43
26	Senior government or UN policy director	<1k	Global	38
27	Senior government or UN policy director	other	National	47
28	Senior executive	10–25k	Global	36
29	Head of sustainability	10–25k	National	46
30	Senior government or UN policy director	other	Other	65
31	Senior executive	<1k	National	59
32	Senior executive	<1k	National	59
33	Head of sustainability	10–25k	Global	43
34	Head of sustainability	10–25k	National	44
35	Board	10–25k	National	44
36	Senior executive	other	Global	65

37	Board	5–10k	Global	57
38	Head of sustainability	5–10k	Global	57
39	CEO	other	National	Written
40	CEO	other	Global	Written
			Total	1820
			Average	48

The interviewees were representative of firms that mostly had a global or regional footprint (57%) and had staff levels mostly from 1–25,000 (62%), and they were mostly at, or above, senior executive level (defined as having "director" in their role title), including nearly a third at CEO or board level who reflected individuals who could represent their firm's views.

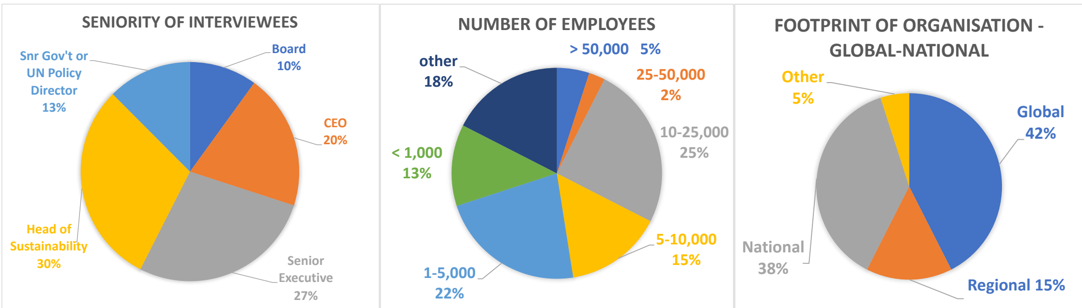


Figure 52. The attributes and values of the forty interviewees.

6.3.2 Development of the Twin-Track Analysis Protocols, Balancing Qualitative with Quantitative Data Collection

As discussed earlier, the preferred approach was aligned to Frels and Onwuegbuzie approach (2013), who had proposed that even within a specific method choice, such as interviews that are qualitative-dominant, it is appropriate to collect quantitative data during the qualitative interview process. The practical application of the "qualitative-dominant crossover" is shown below in Figure 53, which illustrates a twin-track analysis method, which complemented the use of quantitative and qualitative data collection.

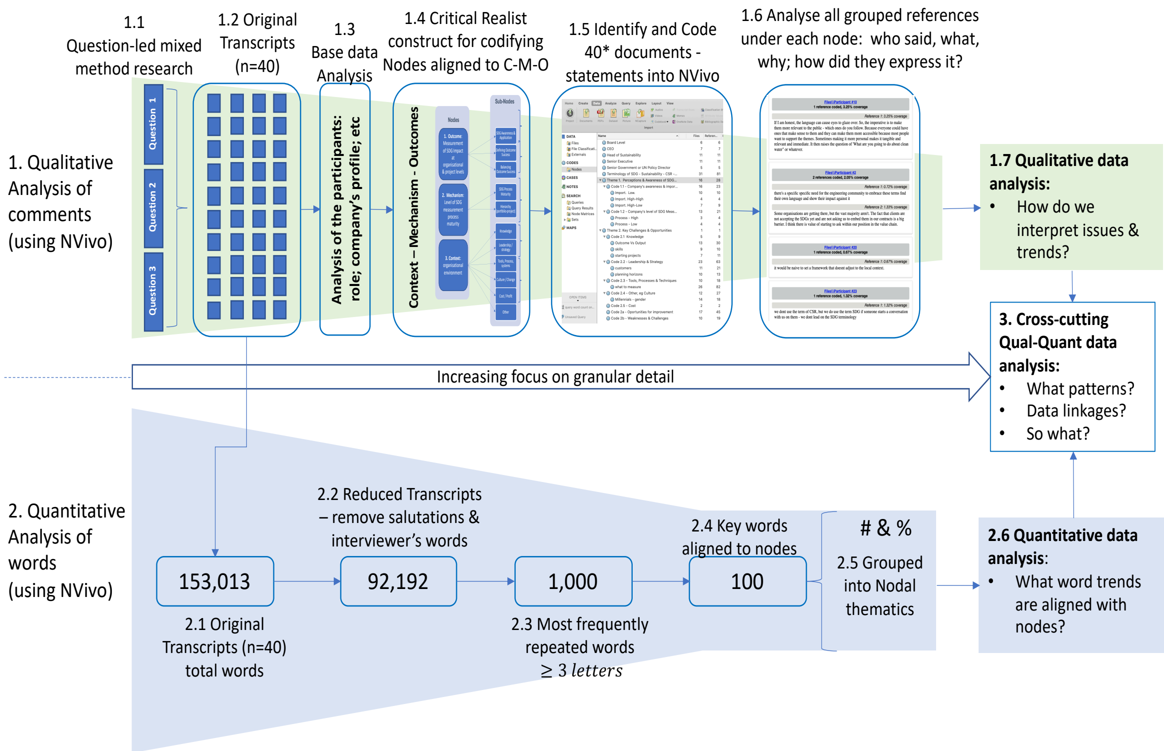


Figure 53. The twin-track analysis protocols approach: qualitative and quantitative.

6.4 INTERVIEW ANALYSIS PROCESS

All interviews were conducted in person and lasted an average of 48 mins (min = 36; max = 75 mins). With the participants' agreement, interviews were recorded using a digital recorder supplemented with hand-written notes. Later, the transcriptions, using the Trint© software tool, were uploaded onto NVivo© and were then compared and coded using the qualitative data analysis software.

The data was analysed at two levels. Firstly it was analysed using textual analysis and then secondly it was 'made sense of' by using themes and pattern interpretation. Based on the nodal structure described earlier and using the parent-child branching technique (Figure 51), it provided an efficient and effective mechanism to capture and link themes but did not in itself provide any analysis. The analysis took place using nodal coding, which was aligned to the three research sub-questions, based on the realist evaluation C–M–O thematics (Creswell, 2017), and each transcript was coded at three levels: first, second and third level coding. The frequency of participants' statements that were selected for coding, and also the relative frequency of nodal use, is shown in the bar charts in Appendix 8. These groupings of statements under each node were then analysed for similarities and aligned with emerging themes.

In addition to the primary analysis approach discussed above, the study included text mining analysis. This is a commonly used methodology for social scientists (Mische, 2014) because it enables the researchers to manage and quantify large amounts of data in a very short time.

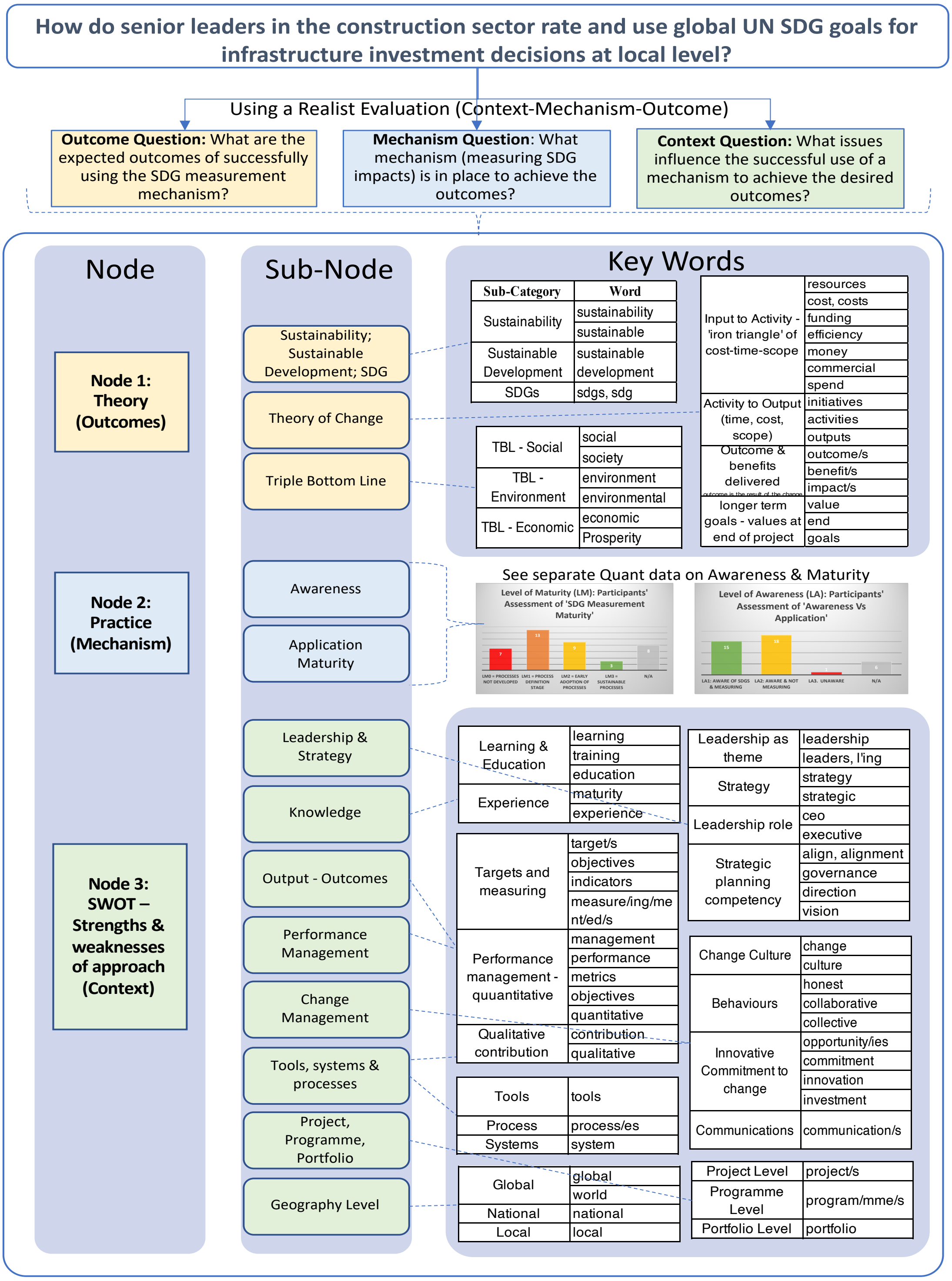


Figure 54. The nodal framework used for identification of key words aligned to context–mechanism–outcome (C–M–O) (Creswell, 2017).

6.5 VERIFICATION

The verification was completed after the interpretation of the data analysis. This involved presenting the findings in 3 workshops (typically 2 hrs long) hosted by the Institution of Civil Engineers (illustrated by the Blog shown at Annex 6) to leading practitioners and academics, organised by the ICE's Knowledge Team Manager.

6.6 RESULTS

The results and discussion are structured in three sections that relate to the three sub questions, as shown in Figure 51, that stem from the primary research question: 'How do senior leaders in the construction sector rate and use global UN SDG goals for infrastructure investment decisions at the local level?'. From this, the derived subsections were as follows.

- **Thematic area 1: outcome.** What are the expected outcomes of successfully using the SDG measurement mechanism?
- **Thematic area 2: mechanism**. What design criteria enable the mechanism (for measuring SDG impacts) to achieve the outcomes?
- **Thematic area 3: context.** What issues influence the successful use of an SDG measurement mechanism to achieve the desired outcomes?

Using the twin-track analysis approach (Figure 53), which includes both the qualitative and quantitative data, results were derived from the combined findings. All participants were asked for their views on the strengths, weaknesses, opportunities and threats (SWOT) of the employment of the MISI mechanism. Given the semi-structured interview approach, their responses did not take a standard route and the interviewer used the funnelling technique (Kallio et al., 2016) to increase subject specificity where depth of answer was required.

6.6.1 Thematic Area 1: Outcome. What Are the Expected Outcomes of Successfully Using the SDG Measurement Mechanism?

The "Outcome" section is the first of three thematic areas that focused on the broader organisational ambitions of sustainability, sustainable development and SDGs. The results were collated under the following headings: the challenge/problem, the opportunities and the imperative for change. This thematic node collected the second highest (out of 23 nodes and sub nodes) number of references (n = 81) in NVivo for leaders' views on the expected outcomes.

6.6.1.1 The Challenge/Problem

The essence of the problem was articulated by Participant 10: "*The weaknesses of the impact measures relate to some of the quantification of it in that there is no standard way of doing it and therefore quantifying impact is very difficult…. The leadership is not fully bought into it. It could be you have not got sufficient good tools for learning and education behind it. There is a lack of consistency in the data of how you measure it and the people measure it in different ways and people will have different perspectives of what good looks like*". These views are similar to those of Participant 26, who also noted the level of complexity, especially when positioned in a global context with the inherent cultural variations, which is potentially why so many participants only claimed to measure the SDGs at a high level: "*This is so complex and it is so different if we are doing things in different countries with different organisations across different environments*".

6.6.1.2 Overarching Opportunity

There were many participants that identified opportunities for improvement, and these are mostly captured under section three on "Contexts". The ambition, noted by many, was summed up by Participant 26, who was from an international organisation and who gave this insight into his global organisation's aim: "*In three years' time we would like to be in a position to have enough information based on evidence and frameworks in place so that we can have better conversations earlier on with clients about what the potential benefits are for the project and why we should be doing projects possibly in a different way than given to us by donors and others*". He continued by anticipating the broader causal impacts of having this mechanism in place: "*So, if we understand the linkages and contribution projects can have across several SDGs, and how that impact could be measured, then we can have better conversations to understand where people should be investing their money and how, and what other aspects to bring into our project to ensure long-term sustainability*". This places emphasis on using the SDGs to make better investment decisions, which becomes one of the critical success factors of the employment of this mechanism. The upbeat message was also shared by Participant 40, a Spanish former President of a world engineering institution: *"Without any doubt, today is a window of opportunity for future SDG impact measurements just for the sake of the pure nature of the new technologies we are using, such as nanotechnology, Biotechnology, Artificial technologies, new material , advanced manufacturing … all of them allow easier measurements procedures."*

6.6.1.3 Imperative for Change and Commitment to Measure SDGs

Participant 13 explained the key part that SDGs contribute to the company's approach to the broader sustainability agenda: "*The SDGs and our impacts on them are of huge relevance to our industry. We are already fully committed to measuring our impact across the triage of economic, social and environmental sustainability themes. Our leadership is fully committed to owning delivery success against these targets, which we jointly assess with our tier 1 contractors. It is now considered core business to ensure the right levels of scrutiny and governance to manage sustainable development performance. In future, this will include measurement against SDG targets but, for now, we need to find a practical method for doing this well*." The final comment in the extract highlights the difficulty of moving from "knowing to doing". Another Participant shared some important progress for measuring sustainability: *"Progress on achieving sustainability targets is improving. Clients and stakeholder are now demanding a higher level or sustainability performance reporting with clear metrics to gauge success."*

Many commented on the link between SDG measurement and their company's values. For example, Participant 5: "*because our purpose is far more than simply generating revenues for shareholders… for us, it is about influencing those solutions to provide the right long-term infrastructure for society. So, we provide jobs and the right training, and we provide the infrastructure we need to connect life together; everything we do depends on it—to try to capture the way we go about doing that in more modern ways for future societies*". Although many were better able to relate progress stories with their sustainability measurement, there were others, such as Participant 28 who aligned with SDGs: "*the whole world has decided how it can be rapidly made better, so the 169 SDG targets are a compass for humanity*". This global connectiveness for companies was a common theme, especially amongst the senior stakeholders, such as Participant 19: *"The global challenges that have led to the SDGs are the same as those that are affecting the viability and commercial success of* *businesses … the SDGs have recognised we are all in it together – and importantly provide a collective vision of the future that every country has signed up to. This is the 'carrot' for new business opportunity. The 'stick' is the risks that businesses face if they do nothing. The way forwards is Creating Shared Value which is more than Corporate Social Responsibility."*

The theme of creating shared value (Porter and Kramer, 2019) was commented on by a number of participants (2, 5, 8, 10, 11, 13 and 19), one of whom, a CEO, commented, "*Since becoming Responsible Business of the Year, we have been working hard to show others how sustainability makes good business sense*." This quote emphasises that the notion of creating shared value (CSV) (Porter, 1985 and 2011), whilst not always using the specific language of CSV, is a growing reason to engage with SDGs and sustainability more generally. It implies that the business priorities can be balanced; a strategy that focuses on the environment and society, which can equally achieve economic success. When in harmony, real growth is delivered to the benefit of all, as shared by Participant 11: "*For example, our approach to 'product lifecycle management' was learned from the aeronautical and automotive industry from 2004-5 and this meant that we looked at the whole life costs, which not only ensured we were more outcomes focused, but by the way, improved our productivity by three percent each year, year on year, highlighting that good sustainable development also made good business sense".* The same senior executive also noted "*so, we thought long and hard about, not just the goals that we created, but how did that fit with a set of longer-term outcomes in our region and what that would look like in terms of implementation. This was our way of meaningfully connecting the strategy with outcomes that our stakeholders recognised*."

The global context and the relationship of the global SDG goals to businesses was a common theme, as indicated by Participant 24, head of infrastructure for his company, who said "*in a world where populations are increasing, cities are expanding and the effect on our environment is more apparent than ever before, the need for infrastructure that is affordable, sustainable and effective is vital. Engineers have a pivotal role to play in designing infrastructure that is not only effective but does not harm the environment in which we live*".

The first major finding derived from this analysis is as follows.

Finding #1: to achieve the outcomes of measuring SDG impacts at subnational level, business priorities can be aligned across economic, environment and society ambitions, and it can make good business sense to do this.

6.6.2 Thematic Area 2: Mechanism. What Mechanism (for Measuring SDG Impacts) is in Place to Achieve the Outcomes?

The second area of discussion was for the Participant to self-assess their company's "awareness and application" and also, if they were applying SDGs, what was the level of process maturity of their SDG measurement. The data in Figure 55 shows the feedback from the participants when they were asked to score themselves against a Likert-style scale, as shown in the first row in columns c and d. The aim of this assessment was to establish a baseline to better understand their level of awareness of SDG measurement and their self-assessed level of process maturity.

a	b	c	d	e	f	g	h
Participant ID	Role in Company	Awareness Vs Application (1=aware & doing; 2=aware & not doing; 3=unaware & not doing)	Your Company's Level of Maturity in SDG Measurement (0=process not developed; 1=definition developing; 2=early processes in place; 3=using sustainable processess)	Participant ID	Role in Company	Awareness Vs Application	Level of Maturity
1	Board	n/a	n/a	21	Board	2	1
2	Senior Executive	1	2	22	Head of Sustainability	2	1
3	Head of Sustainability	1	3	23	Head of Sustainability	2	0
4	CEO	2	1	24	Senior Executive	2	0
5	CEO	1	2	25	Senior Executive	1	1
6	Senior Executive	1	2	26	Senior Government or UN Policy Director	2	1
7	CEO	3	0	27	Senior Government or UN Policy Director	1	n/a
8	CEO	2	0	28	Senior Executive	1	2
9	Head of Sustainability	1	2	29	Head of Sustainability	2	1
10	Senior Government or UN Policy Director	2	1	30	Senior Government or UN Policy Director	2	0
11	Senior Executive	1	2	31	Senior Executive	n/a	n/a
12	CEO	1	2	32	Senior Executive	n/a	n/a
13	Senior Executive	2	0	33	Head of Sustainability	2	1
14	CEO	1	1	34	Head of Sustainability	2	0
15	Head of Sustainability	2	1	35	Board	2	2
16	Board	1	1	36	Senior Executive	2	n/a
17	Senior Executive	1	2	37	Head of Sustainability	2	1
18	Senior Government or UN Policy Director	n/a	n/a	38	Head of Sustainability	2	1
19	Head of Sustainability	1	3	39	CEO	n/a	n/a
20	Head of Sustainability	1	3	40	CEO	n/a	n/a

Figure 55. Results of the self-assessed level of awareness-application and process maturity (colour representation shown in columns c and d in titles row).

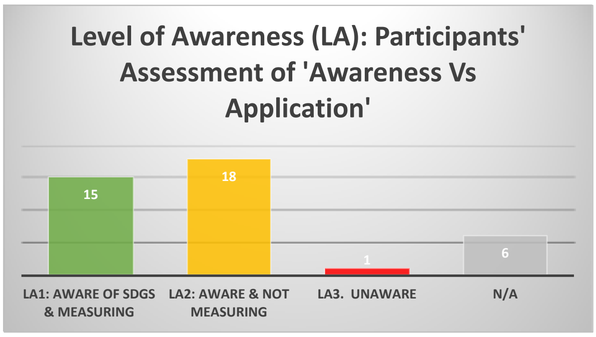
6.6.2.1 Company's “Awareness and Application” of SDG Measurement in Construction Projects

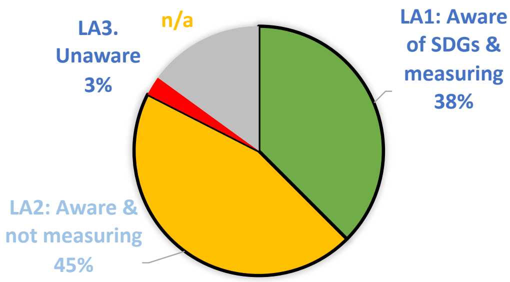
As part of the interviews, all participants were asked to describe their awareness of sustainability, sustainable development and SDGs. They were then asked to describe their current level of SDG measurement maturity. The data on these are shown in Figure 55.

At the lower end of the spectrum (level 3 = unaware and not doing it), Participant 37 admitted that, regarding “*the United Nations Sustainable Development Goals, I had never heard of them—a request for an interview came through and [name withheld] only heard of them through a bid we were working on that included an SDG question. The SDGs have no current place in our business*”. As this was a board member, this was surprising because it was expected, in the opinion of the researcher, that senior management would have some level of SDG knowledge. But there were others that also had low levels of knowledge, such as Participant 16, from a large global construction firm, who stated “*I'm not sure people in the industry seem to be doing this - they are trying to do things responsibly but in a way that fits with their agenda and their clients' agenda. For us we don't utilise the SDGs*”. Participant 7 was equally open: “*I would say we are unaware and not doing it*”. This honesty was common amongst interviewees, such as from Participant 21: “*Have the workforce bought into the sustainability approach and especially the SDGs? Well, I have to be honest, and I will answer this as honestly as possible - so our level of understanding is very low*”.

In the middle range (which was “aware and not doing” e.g. not doing refers to not measuring the SDGs, so they are aware and doing, but not systematically, including measuring), representing 47% of the participants, Participant 4's answer was typical: “*Awareness is that we are doing some discrete things but not in any depth*”. The reasons for this varied, but a common theme was that there was not a requirement from governments or clients, as Participant 21 shares: “*We do not have a demand from our clients or from our communities that we work to measure against the SDGs. Like many in our industry, these are not common terms that we use… we do not have as much benefit from embedding them as much as a large global company that perhaps needs to demonstrate SDG impact more visibly. A lot of the things we do implicitly encompass the SDGs, but we are not explicitly measuring against them*”.

In the higher range, which was "aware and measuring", represented by 38% of the participants, there were some examples of significant progress, such as that shared by Participant 7: "*Every single project in the organisation will feed into SDG number 11—'sustainable cities and communities'—and every project in the organisation will address at least 4–5 of the SDGs*". Some qualified their answers to suggest that they are not measuring SDGs to complete a 'tick box' exercise, but instead, as shared by Participant 10: "*I think we definitely are aware, definitely doing it, but we are doing it anyway, not because of the SDGs, because it is the ethos of our organisation, and we do it because it is the right thing to do - but the SDGs provides a useful framework to structure and report on this work*". However, there were others that identified the SDGs as being a good reason to change the way they reported, as commented by Participant 19: "*Since 2000 we have been reporting on sustainability KPIs, that we refreshed in 2014; sustainability is well established. SDGs represent a new chapter and we have made a commitment to SDG and Paris Declaration and Sendai Agreement. Our strapline is 'Shape a Better World' thus it makes sense for us to align with SDGs and spell out what better looks like in 2030. However, the issue of reporting against SDG's is a hornets' nest*".





(n = 34 completed answers of 40)	#	%
LA1: Aware of SDGs and measuring	15	37.5
LA2: Aware and not measuring	18	45
LA3. Unaware	1	2.5
n/a	6	15
total	40	

Figure 56. Graphical representation of results from self-assessed level of "awareness-application".

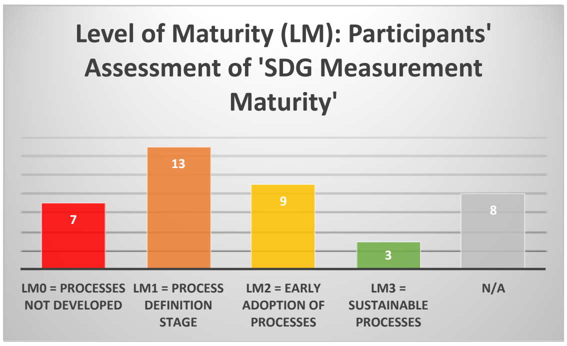
6.6.2.2 Company's Level of SDG Measurement Process Maturity.

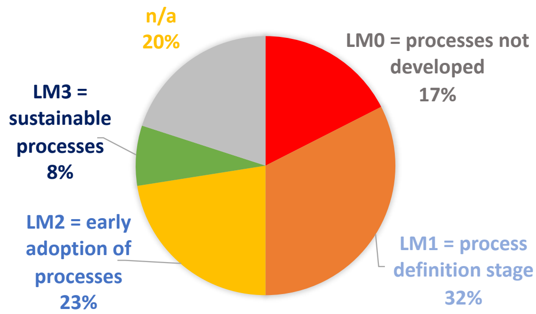
As part of the interviews, the second quantitative question all participants were asked was to describe their current level of SDG measurement maturity. The data on these are shown in Figure 56. The banding levels for this question were: 0 = no SDG processes, 1 = currently defining processes, 2 = early processes in place and 3 = sustainable SDG processes. Overall, the quantitative data showed that nearly half (49%) were at level 0 or level 1, which meant that no mature processes were in operational use. Only 23% stated that they were at level 2, the early adoption stage of processes, with a very small group (8%) stating that they had repeatable processes in place.

One of the best, Participant 13, stated: "*We are at Level 3, we have managed processes, metrics and quality management*", which was similar to Participant 23: "*we have some consistent ways we do things that are aligned to SDGs, but we do not look at every SDG and answer how they contribute to the goals. But we do cover a lot of the issues at project level*".

In reality, many of the participants only conducted measurement at a high level, such as Participant 34: "*In the past we have done a review to see how our strategy fits with the SDGs. We found that the SDGs were impacted by our work, some more than others, in terms of the goals and targets; they are not particularly relevant to the work that we do so our priorities have been elsewhere and therefore our resources have been focused elsewhere*". About a third of the participants said that they could, at a high level, link their SDG priorities to the formal sustainability reporting that they did on the Global Reporting Index (GRI), such as Participant 26, who stated: "*Well, we are all aware and starting to do it. We started using the Global Reporting Index framework on sustainability three years ago and we started reporting on our corporate results yearly on that but, at the project level, we have been a bit slower pushing up to that*". This theme of doing more measurement at a high level, more at the corporate than the project levels, was also shared by Participant 2, who stated: "*We at least have already produced an integrated SDG report that shares material commitments from our business - so we are already using the SDGs as connectors to open opportunities*". Amongst the lowest performers was Participant 9, who stated: "*in terms of SDG reporting processes we are close to 1. Our maturity is still low, although our sustainability reporting is much higher. We have not yet made it integrated to SDGs and have not yet generated a report against them. That is what we are talking about now and what we want to achieve*". This was similar to Participant 23, who also accepted their immature status, but balanced this with a strong ambition to do better: "*we have some consistent ways we do things that are aligned to SDGs, but we don't* *look at every SDG and answer how they contribute to the goals. But we do cover a lot of the issues at project level*". At the lowest level, there was also some surprisingly open admissions, such as Participant 26: "*Very little going on… in terms of SDG impact measuring on engineering products - very little.*"

One of the insightful links for increasing SDG measurement maturity was what Participant 2 referred to as a value chain and the need for the government and clients to increase the relative importance to measure against SDGs: "*My ambition is that we are all at level 3 maturity. All the players in the value chain, but this means that clients and governments need to be high up on the scale. I can't drive it from my position*".





	#	%
LM0 = processes not developed	7	17.5
LM1 = process definition stage	13	32.5
LM2 = early adoption of processes	9	22.5
LM3 = repeatable processes in place	3	7.5
n/a	8	20
total	40	

Figure 57. Graphical representation of results of the self-assessed level of "SDG measurement maturity" (colour representation shown in Figure 8 in column h in the titles row).

The second major finding derived from this analysis is as follows.

Finding #2: only a small percentage of companies have a repeatable process as an operational "mechanism" for measuring SDG impacts at company and project levels. Most have an aspiration to do so but believe that the government and their clients need to mandate its implementation.

6.6.3 Thematic Area 3: Context. What Issues Influence the Successful Use of an SDG Measurement Mechanism to Achieve the Desired Outcomes?

The analysis of the contextual issues that affect companies' ability to measure SDG impacts successfully were captured using a strength, weakness, opportunity and threat (SWOT) approach. The eight themes are shown in the nodal framework in Figure 54 and include: leadership and strategy; knowledge; outputs-to-outcomes; tools, processes and systems; change management; performance management; project-to-portfolio levels; and geographic issues. These were all derived from the preceding survey of 325 engineers. The qualitative analysis shared below is complemented by using the twin-track approach described earlier, which includes the text-analysis software-enabled word-count data. The approach was to identify key words and relate their frequency of use to the qualitative findings to assist the understanding of the emerging issues. For example, in this first context thematic, "leadership and strategy", the key words associated with this thematic are: leadership (and its derivatives, such as leader), strategy, CEO/executive and align/governance/direction/vision, which are all words associated with leadership capabilities and actions.

6.6.3.1 Leadership and Strategy

For the leadership and strategy node, there were high levels of relevant statements coded (n = 63) from the 40 participants (using the NVivo software), reflecting the importance of this thematic. In terms of key word usage, this thematic was the fifth most frequently used (n = 584) across the 40 interviews, which equates to once every 120 words. Within this category, the frequency of use of "align", "governance", "direction" and "vision" were noted since these words are all associated with leadership capabilities. This potentially reflects the seniority of the participants who all had roles and responsibilities that focused on strategy setting and alignment across their stakeholders, internally and externally. This also partly explains why there was more emphasis on strategic discussions and less on the tools and processes of measurement, that had the second lowest (out of 8) word frequency usage.

The most impactful statements collected were the frequent references to a "greater value" beyond profit. This sentiment sits well with creating shared value and the triple bottom line discussed earlier. This viewpoint was personified by Participant 11: "*a key part of leadership is doing the right thing because it is the right thing to do,* *not because of a box-ticking exercise*". The same participant also focused on the difficulty of making the change stick: "*It is 50% belief and 50% belligerence when you start something like this; that is, holding yourself and others to account. That is what I mean by belligerence. In other words, 'seeing it through' and what we wrote down as a mantra: 'Don't you understand'*". In his view, as a senior executive, he stressed the important role of his CEO and Board: "*Leadership is the most important critical success factor, both internally and externally, to align and galvanise our employees, our communities and the supply chain. It was about getting us all to be more collaborative in finding novel, innovative ways of delivering sustainable solutions…. It is about the leaders capturing the hearts and minds of the stakeholders to champion changed behaviours to achieve big, bold strategic outcomes*." He also noted the moral values that are implicit in the choice of making sustainable development a core business priority for his company. The reference to the core principles of governance (OECD, 2015) of accountability, responsibility and transparency were also noted: "*a key part of the leadership is the ownership of the sustainable development strategy. It is also about accountability and having the resources to deliver the solution. That is why the 'Infrastructure Clients' are the single most important stakeholders in addressing sustainable development. If they 'own' and champion the solution, then the supply chain will follow… hence leadership and procurement are the biggest elements of the recent Green Construction Board's 'Three Years On Report – Reducing Carbon Reduces Cost' report*" (Green Construction Board, 2015).

In terms of strategy, one organisation noted the importance of the "ends, ways, means" logic similar to the Theory of Change concept (Carol Weiss, 1972, 1983, 1995, 2005). Participant 9 stated: "*you must start with the end in mind, even if you have not got a detailed route map to deliver at every stage of the journey. Part of the mantra is to set big audacious goals and then adopt an attitude of 'I have started so I will finish' and, by the way, you never actually finish, because the end goal is moving, it is like you achieve one peak but realise it is a false horizon, and so you continue your climb to the next summit*". The value of having clarity of the strategic ends is noted, albeit with a caution that the identification of targets for tracking performance must not become a "box-ticking" exercise that distorts clarity of outcomes. Participant 11 stated: "*if you actually begin with the end in mind of the outcome you are seeking and* *how you wire your DNA to achieve that, you are far more likely to achieve those outcomes and, in so doing, the boxes get ticked. But if you predicate your thinking with thoughts about just filling the boxes, you have constrained yourself*". *Most of the participants linked leadership with strategy, as described by* Participant 11: "*a key part of the leadership is the ownership of the strategy. It is also about accountability and having the resources to deliver the solution. That is why the 'Infrastructure Clients' are the single most important stakeholders in addressing sustainable development. If they 'own' and champion the solution, then the supply chain will follow… hence leadership and procurement are the biggest elements of the recent UK Cost of Construction reports*."

Table 15: Text analysis (NVivo) on key words' frequency: context of leadership.

Category	C-M-O	Sub-Category	Word	Count	f1 Word %	f2 Sub-Cat %	f3 Cat %
Leadership	Context	Leadership as theme	leadership	83	0.16%	0.29%	0.80%
			leaders	30	0.06%		
			leading	20	0.04%		
			leads	15	0.03%		
		Strategy	strategy	75	0.14%	0.18%	
			strategic	23	0.04%		
		Leadership role	CEO	26	0.05%	0.12%	
			executive	37	0.07%		
		Strategic planning competency	align	25	0.05%	0.21%	
			governance	25	0.05%		
			alignment	18	0.03%		
			direction	18	0.03%		
			vision	28	0.05%		

Finding #3: strong leadership plays a significant part in inculcating SDG measurement as an ambition and core value into an organisation.

Finding #4: the more advanced businesses in SDG measurement noted the need to have a clearly defined strategy that can guide the prioritisation of SDG goals using the "ends, ways, means" model. This requires clarity of the "ends" prior to defining project success (in-project and post-project).

6.6.3.2 Knowledge

For the "knowledge" node, there was a relatively smaller incidence (n = 19) of relevant statements coded from the 40 participants (using the NVivo software). In terms of key word usage, this thematic was also one of the least frequently used, with “learning”, “education” and “experience” being used only 140 times across the 40 interviews, which equates to once every 400 words.

The qualitative analysis identified a strong preference for using education and training to improve their staff’s SDG impact skills and business skills, especially in the wider definition of success, which is related to the later discussion of outputs-to-outcomes. An indication of the importance of this was provided by the CEO of one global engineering company, Participant 7: “*So, how do we galvanise our community, how do we tell our story better against the SDGs and how do we galvanise our community to be able to share best practices, and what does that mean for education and training?*”. Another, Participant 25, a national utility senior executive noted: “*How can we share knowledge and understand what we can learn from each other? Could learn a lot from one another*.” This illustrated that there is a general consensus that we can all learn from each other, as stated by Participant 3: “*we are going through a huge amount of learning ourselves but certainly around measuring impact yeah it's quite an interesting stage at the moment*”. It was evident that many identified this as a key leadership responsibility, such as Participant 3: “*place emphasis on the leadership role, the key leaders in talking about learning and education*”.

Learning lessons from success and failures was mentioned by Participant 15: “*how do we share knowledge - how can we be more effective and efficient - so how can we avoid repeating the same old problems*”. Similar to learning lessons is having a feedback loop, as one Participant said (23): “*so we have a range of communication events, such as sustainability weeks, when we shine a spotlight on how we're doing on those issues*”.

Skills covered a number of areas, including the skills to be able to define success definitions, business skills to be able to build performance frameworks and sustainability/SDG skills that helped understand the SDG framework and how they relate at sub global-national levels and at organisational and project levels. Participant 3 stressed its import: “*I think the skills piece is the second most important area because we cannot expect our people to deliver on these KPIs if they do not know what they mean and if they do not know how to measure them and improve them, so investing in how to calculate social value and improve upon them and investing in training in* *social value RoI is very important; it gives us an opportunity to benchmark and improve on it*".

Overall, participants seemed to accept that, despite the current supposed level of SDG measurement awareness, there is also a shortage of trained personnel to support the implementation of SDG measurement on their construction projects. The closing of this gap reflects the views of Reffat (2004) on the insufficient number of human resources with the required skills to perform sustainable development on construction operations.

Table 16: Text analysis (NVivo) on key words' frequency: context of knowledge.

Category	C-M-O	Sub-Category	Word	Count	f1 Word %	f2 Sub-Cat %	f3 Cat %
Knowledge	Context	Learning & Education	learning	30	0.06%	0.15%	0.26%
			training	22	0.04%		
			education	29	0.05%		
		Experience	maturity	30	0.06%	0.11%	
			experience	29	0.05%		
				140	0.26%		

Finding #5: learning and education plays a critical role in increasing capability and, specifically, in understanding how to better share lessons on SDG measurement for the good of all.

6.6.3.3 Outputs-to-outcomes

The "outputs-to-outcomes" node had the fifth highest incidence (n = 30) of relevant statements coded from the 40 participants (using the NVivo software). In terms of key word usage, this thematic was also one of the most frequently used (shown in the "Theory of Change" key word table, Table 17), with the first half of the causal chain (input, activities and outputs) being cited as frequently as the second half of the value chain (outcome to impacts). This was significantly less than the general reference to longer-term benefits that were synonymous with key words such as "value", "ends" and "goals", which were used 339 times across the 40 interviews.

Within this subcode, most recognised the challenge of differentiating between outputs and outcomes. Too few knew how to do this well and, as a result, the wrong "targets indicators" were sometimes being used to measure success. Participant 8, a

CEO of one of the UK's largest infrastructure programmes, said: "*programme and project people are sometimes less aware of how we are doing strategically if you are not careful. So, they can often have a bias for cost and schedule focus and lose focus on other priorities we have set*". Another way of expressing the inappropriate focus on outputs came from Participant 3 (repeated quote): "*we know that, if we just design to code, we end up with projects that are great for today but absolutely do not meet the future that we are expecting*". This was expressed very clearly by Participant 19: "*We also need to talk in terms of outcomes and impacts. We need to change the dialogue of engineers so that they talk less about output and more about outcomes. Engineers typically focus on what we build, eg roads, water systems, buildings etc. We need to build a different narrative to help engineers of the future, and today, to see the role of engineering in society – in a way, it goes back to the early roots of engineering*".

Some organisations have fully embraced the strategic aim of better aligning with outcomes, such as Participant 11: "*So we thought long and hard not just about the goals that we created but about how they fitted with a set of outcomes in our region and what that would look like in terms of implementation. This was our way of meaningfully connecting the strategy with outcomes that our stakeholders recognised*." The same person described the need to look at the end first to better understand ambitions: "*you must start with the end in mind, even if you have not got a detailed route map to deliver at every stage of the journey*". He goes on to say: "*part of the mantra is to set big audacious goals and then adopt an attitude of 'I've started so ill finish' and by the way, you never actually finish, because the end goal is moving, its like you achieve one peak, but realise it is a false horizon, and so you continue your climb to the next summit*."

One of the most common reasons for the overemphasis on "outputs" was shared by Participant 26: "*So, the measurables are very weak in terms of linking the engineering and the infrastructure impacts to the higher programme. It is just about 'have you built the hospital' as an output*". This was expanded on by Participant 36, who gave a useful example of what she meant: "*One of the key things as we look at the evidence that's provided in the assessment is that actually deciding whether you're delivering the right solution isn't always at a project level. It's often a much bigger level. So, for instance a project to take a relatively simple example, a project might be*

10 miles of road by-passing a village. If you just look at that 10 miles of road, doing a bypass might be deemed to be the wrong thing to do. But if you put it in to the context of Highways England route management plan that 10 miles might be a very critical part of 100-150-mile-long route. And that 10 miles might be absolutely critical to economic growth, solving problems somewhere else. So therefore, the downside to building that village bypass, if you just assess it at a village bypass level it's the wrong thing - they shouldn't be doing it. But if you assess it on a bigger boundary and think about the route, then it puts it into a completely different context". One Participant (27) shared a solution to the problem discussed above: "*I think we have our theory of change in place now. People are required to produce logframe to explain how they are feeding into the theory of change*". This proposal gives an important insight into how the linkage of outputs to outcomes can be improved: "*at the moment we have one annual report which sets out the theory of change of what we're doing, this helps align key partners to what the ends are*".

The cost of implementing SDG measurement was another key issue. According to Participant 26, the SDGs are complicated and not easily adopted and since few clients are willing to pay for it, it is deemed unnecessary. This aligns with the Zhou and Lowe (2003) study that noted general agreement that 'green' construction is more expensive when compared with regular buildings and that SDGs might also weaken the bottom line profits. These cost/profit realities were noted by Participant 6: *"We all understand that we're in a place where everybody in our market and business is working for the best outcome for the lowest cost. The trick is to define what we mean by best outcomes and lowest cost means." – "lowest cost ends up with high maintenance costs, or multiple defects, and best outcome is rarely the lowest cost - so in the context of sustainability goals, then both those definitions need to have much more nuancing around them, so people who understand why they want to do things rather than just for the purposes of the financial elements, which are part of it of course, but not by any means the entirety of it".*

Table 17: Text analysis (NVivo) on key words' frequency: mechanism/context of the Theory of Change.

Category	**C-M-O**	**Sub-Category**	**Word**	**Count**	**f1 Word %**	**f2 Sub-Cat %**	**f3 Cat %**
Theory of Change, (causal logic chain	Mechanism		resources	20	0.04%	0.33%	1.26%
			cost	57	0.11%		

from inputs to impacts)	Input to Activity 'iron triangle' of cost-time-scope	costs	17	0.03%	
		funding	16	0.03%	
		efficiency	16	0.03%	
		money	18	0.03%	
		commercial	17	0.03%	
		spend	17	0.03%	
	Activity to Output (time, cost, scope)	initiatives	27	0.05%	0.12%
		activities	15	0.03%	
		outputs	19	0.04%	
	Outcome and benefits as result of change derived from project's outputs.	outcomes	60	0.11%	0.17%
		outcome	34	0.06%	
		benefits	23	0.04%	
		benefit	19	0.04%	
		impact	219	0.41%	
		impacts	19	0.04%	
	longer term goals—values at end of project	value	101	0.19%	0.64%
		end	73	0.14%	
		goals	165	0.31%	

Finding #6: the use of the log-frame and Theory of Change provides a means to link outputs to link outputs to outcomes and better identify SDG impacts.

6.6.3.4 Tools, Processes and Systems

The "tools, processes and systems" node had one of the lowest incidences (n = 18) of relevant statements coded from the 40 participants (using the NVivo software). This suggests that senior executives and CEOs have less interest in, or place lower value on, specific tools or methodologies, which might indicate why this is an underinvested area. In terms of key word usage, this thematic was also one of the least frequently used, shown at Table 18, with "processes" being cited twice as frequently as "tools" and "systems". In total, they were used only 177 times across the 40 interviews, which equates to once every 300 words.

The survey (Mansell et al., 2020) that preceded these interviews had identified a common reference to the lack of tools, systems and methodologies. This was not proven in the interviews, although a number of the heads of sustainability (3, 9, 15, 20 and 29) were more likely to mention this as a factor. On the ability of the sector to galvanise and align with a consistent approach, Participant 18 highlighted that there were bigger issues to deal with prior to designing a tool: "*I think it is essential. I have very little confidence in our ability to do it now. Even if you had a decent methodology* *now, I suspect very few people would use it and you probably have a number of competing methodologies, which is typical in this sector*."

However, others, such as Participant 20, said: "*for me the tools and processes underpin the delivery because, without them, you cannot possibly know where you are or where you need to go*". This was consistent with Participant 18, who shared their organisation's investment in this area: "*we're going to have the new management methodology in place soon, which is improving our ability to provide that consistency in this centrally controlled process and then building into the electronic the enterprise system*". This need for investment in tools, was also shared by Participant 1: "*tools, a framework and methodology are all needed to actually report against and see some quantitively proven success*". But a key element of the design of a tool was to get the balance right between being too complex and being at the other end of the scale—being too high level and therefore superficial—as noted by Participant 10: "*I think, in most cases, a consistent framework or reporting approach would be helpful; that gets the balance right between having something that is consistent but watered down to such a high level that it loses meaning, versus having too much detail that is too granular, loses the users in too much complexity and is difficult to fit with your business model and the way you report things into that*".

Table 18: Text analysis (NVivo) on key words' frequency: tool, processes and systems.

Category	C-M-O	Sub-Category	Word	Count	f1 Word %	f2 Sub-Cat %	f3 Cat %
Tools, Systems; Processes	Mechanism	Tools	tools	32	0.06%	0.06%	0.34%
		Process	processes	26	0.05%	0.23%	
			process	93	0.18%		
		Systems	system	26	0.05%	0.05%	

Finding #7: the use of tools, systems and processes to measure SDGs is not a priority for CEOs and board members but it is for senior executives and heads of sustainability. These tools need to be simple enough to understand but robust enough to capture detailed evidence that leads to improved performance.

This very interesting finding raises a number of issues such as: why are tools/systems/processes not a priority?; What did they prioritise instead, why, and what does this tell us about the Change (as regards ToC), about the TBL and the IVC? These will be answered and developed in Chapters 8 and 9.

6.6.3.5 Change Management

The "change management" node had an average level of incidence (n = 27) of relevant statements coded from the 40 participants (using the NVivo software). In terms of key word usage, this thematic (shown in Table 19) tracked "change culture", "behaviours", "innovation" and "communications", all of which provided a large number of insights from participants. In total, they were used 410 times across the 40 interviews. However, the quantification of the data does little to indicate that this contextual issue was one of the best sources of insightful knowledge.

There was general recognition from the participants that the single most important area for ensuring SDG measurement success is having a successful change programme that ensures a practical approach is made to work for the "users", with the added value of what they are doing. The starting point for this approach was ensuring the right culture in the organisation, characterised by openness and honesty about the difficulties of measuring SDGs and also closing the gap between superficial statements of intent without having the evidence to back up what they say they do. For example, Participant 15 stated: *"[name of company removed] say that they measure against SDGs, but there is a gap between what they say they do and what they actually do*". The same concern in the honesty of many organisations was noted by Participant 5: "*In Terms of our customer base the honest answer is at the moment our customers pay lip service to this stuff - they talk about it. But in reality, they're not really doing things that make a difference. They don't take decisions or anything like a difficult decision that you might say has been heavily influenced by something on the sustainability agenda. Disappointingly - I hold out hope but that is the facts"*.

The transparency of data is noted by Participant 12: "*trying to get something that is practical, meaningful and simple enough to be understood by your team. We are very open and transparent, what we want to achieve, why and how we are doing against the targets*". Participant 11 makes a similar point: "*It's obvious that you have to make loads of tough decisions rather them duck them, and then recording your progress in an open, honest and visible way, helps keep you honest in that process*."

Many identify the key issue of the change management culture is to capture the hearts and minds of their staff, as mentioned by Participant 2: "*our change program, as much as anything, is getting the hearts and minds of engineers in the field to understand the potential benefit of doing it and that it's not a waste their time"*. As one CEO (12) commented: "*we can only change people's outlook once people are engaged as a workforce - so its core to having a sustainable business. This is a big part of my ethos of the company that they want to work at*" and he also refers to the same theme, "*and I guess there's winning the wider hearts and minds to show them that the global agenda really matters as well*".

Innovation was a frequently referenced benefit of securing the right change culture and, in doing so, having the means to address the SDG targets more effectively. For example, Participant 11 noted the effect of building long-term supplier relationships that enabled more innovative solutions to be developed: "*We wanted to establish meaningful change across the supply chain, and we recognised that, to do this, we had to develop long-term relationships; hence, we contracted on a five-, plus five-, plus five-year basis. This built longevity into our thinking and allowed true innovation to develop solutions to the bigger sustainable development issues across the environment, driving efficiency and effectiveness*." The same benefits of a motivated workforce were shared by Participant 14: "*We've seen teams come back with new solutions, new ways of working, ideas which for us is incredibly innovative. When you boil them down, they are not radical they have just gone and found ways of doing things differently"*. One way that a global Head of Sustainability has increased involvement and excitement was shared by Participant 3: "*I particularly liked the term of the 'engineers as the clever experts', saying that if the future is going to be like this, how would you, as a clever innovative engineer, design differently than what you did before. If you approach it as an innovation function rather than just a sustainability function and you don't get hung-up by trying to persuade everybody that climate change is the most important thing, you depoliticize it and you play it to areas that engineers are particularly up for - which is doing very clever stuff. That is what engineers are there for"*.

Communication was also a dominant theme of culture change. Participant 1 noted: "*you do not communicate it once, you communicate it nearly every day through many, many different vehicles. You bring people in*". Participant 24, a leader of a North

American national civil engineers institution, highlighted the value of leaders who can tell stories that resonated with stakeholders: "people with success stories become your spokespeople and they start to influence others, saying '*hey, you know this works for us' rather than just trying to sell the methodology. It is more, you know, encouraging peers, e.g., peer-to-peer*". This highlights the importance of stakeholders and the communication plans used to share SDG progress. The word analysis identified key stakeholders, including: governments; communities; investors; users; suppliers; and most commonly referenced, employees/staff. This was captured by Participant 26: "*the SDGs requires us to look at partnerships all across private sector, academia etcetera in achievement of the SDGs - it is obvious that we all need to come together".* The main focus for this stakeholder engagement for Participant 11 was: "*Our starting point is understanding what is important to our clients, who want to see us make improvements, and where our staff and employees want to make a difference*". Participant 32 continued this theme across other specialisations, such as lawyers, designers: "*The importance of collaboration with other disciplines still that's great but also apply in areas where landscape architects, accountants and I'm sure others have described to you these goals are not going to be achieved by just one or two groups. They need many people working together with diverse perspectives and diverse backgrounds around the table*". The final cautionary note about communication was that the messaging should be kept simple and accessible, as suggested by Participant 11: "*We found that our campaign and collaborative working with partners had created a different conversation with different language. Ultimately, accessible language on meaningful outcomes are what people can buy into and this is what creates the momentum of changed behaviours…Through engagement, innovative solutions address the big problems, Wisbech is an example of working with the community to achieve meaningful long-term changes*."

Learning from the statements shared above, a good solution proposed by Participant 25 was: "*So individual projects would have their own stakeholders and customer satisfaction and community engagement. So, it varies on the size of project - some are very small and some are spending a billion pounds on a major rewiring in London. But each project has outcomes on all the projects, more than cost, time and quality*." The theme of collaboration was noted by many of the participants, such as a Board member (#1), who linked the collaboration with strong leadership: "*How do* *you seek to build a sort of coalition of the willing to move in that direction*? *I think you do it through visionary leaders - leaders that recognise the big picture and do the part they can play in achieving that. So, I think you win over the leaders and the leaders then lead their companies through it. And they then lead that change".*

Another key theme of the interviews was the issue of millennials. In total, 33% of participants discussed millennials. The preceding survey (Mansell et al., 2020) included a number of specific questions relating to the interests-perceptions-values of millennials and this survey report had been read by some of the participants prior to the interviews. There were some consistent and interesting considerations, especially in senior executives recognising the demands of millennials in this area and the need to adjust their approach in consideration of the recruitment and retention HR issues. For example, Participant 13, a CEO of one of UK's largest transport programmes, stated: "*Young people keen to make a difference, keen to do things sustainably, problem is with more senior people making sure they 'get it' to give young people space to do what they want to do".* Others also noted the role of young people as leaders to galvanise businesses to measure SDGs, as shared by Participant 10: "*I think millennials have a role here as new project leaders where often they are the people who are most energized. I got into engineering to make a positive difference to people's lives*". Many participants recognised the potential power of millennials to change the course of their businesses, such as was noted by Participant 20: "*our biggest influencers are the millennials who are more aware, and they see it affecting them more directly - it becomes a challenge since cultural change of the older generation is more difficult to achieve if they are required to change their routine*". Although another view was postulated by a CEO (#7) who didn't agree: "*No I am a bit sceptical of those Millennial badges of being much more demanding because when I was 20-30 years younger, I had the same passions, I think they might be more of a groundswell, but I was interested in these issues - so I don't like the simple analysis that suggests that millennials do care whereas their predecessors didn't.*" But there were 6 of the participants that mentioned the positive impact on recruitment and retention, as noted by Participant 23: "*being good at these things impacts on the skills shortage by attracting and retaining staff which in a market of shortage is important. It can help us attract retain and motivate good people by presenting good strong ethical company particularly important given our industry faces.*"

An unexpected but often-quoted issue was on the context of gender influence on SDG measurement. Eight participants (1, 5, 10, 17, 21, 24, 31 and 37) made specific reference to gender impact: "*the younger generation really do want to change the world. Interestingly, particularly the female part of that [company name removed] has more than 50% of its membership as female and I pondered why that should be, and I think it is because it appeals to the values of certainly the younger, but actually to the female, side of our institution, who really want to make a difference to the world that they live in. Probably, they are more driven by that than they are by financial reward*". Participant 10 suggested that the reason for the female intuitive importance attached to SDG measurement was due to a natural inclination to be more passionate in this area: "*Quite often some male engineers just love problem solving but are perhaps less passionate about making a positive impact on people - in other words its less about the technical side that motivates me. It is merely the means to the ends*". One senior executive of a global construction company, Participant 24, was open about the value to their business: "*SDGs language is great for attracting the future engineers and get the gender balance right*". A wider value was linked to the diversity agenda by Participant 31: "*The young people coming up are aware of these goals and creates an excitement and there is much to be done - there are things to be figured out and I think it's appealing also to the diversity issue*", which was also noted by another CEO (#5) who stated: "*SDGs support my interest in promoting gender diversity in our industry and about promoting training and development and apprentices recruitment into our industry*."

There were nearly half the participants that promoted the positive effects of harnessing the power of the millennial generation to promote change and thereby help champion the uptake of SDG measurement, which was shared by Participant 1: "*So, if we can find a way of linking into the power of the younger generation*". This attitude was further explored by Participant 10, who noted the obvious fact that millennials are tomorrow's leaders: "*I think millennials have a role here as new project leaders where often they are the people who are most energised*". The beneficial impact on recruitment and retention, mentioned earlier, was described by a CEO, Participant 12: " *… attracting and retaining top talent into the industry, specifically around [location name removed]. It's something that captures the heart of millennials*"… "*getting the right talent here is critical to us. So, to attract the right people across that age group* *we would want to respond in the right ways*." This self-serving reason for using the SDG measurement as a business tool, was also shared by Participant 22: "*We are very aware of our millennial global population and making sure that they are engaged and moving the business that continues to attract and retain that talent*". Approaches to achieve this were given by Participant 25: "… a*lignment to your business success to do the right thing, from the sustainable agenda perspective, and I think that feeds into that cultural point of sort of the hearts and the minds of individuals certainly for the millennials, they are less concerned about pension schemes etcetera, they are much more environmentally focused". He continued later in the discussion: "that comes back to how we treat people and our environmental credentials. There is a clear business reason for recruiting and retaining staff".* Strong evidence of this view was also provided by Participant 3: "*attracting and retaining staff - typically three or four people per week who tell me our sustainable development focus is why they joined our company"*.

Table 19: Text analysis (NVivo) on key words' frequency: context of change management.

Category	C-M-O	Sub-Category	Word	Count	f1 Word %	f2 Sub-Cat %	f3 Cat %
Change Management	Context	Change Culture	change	129	0.24%	0.28%	0.78%
			culture	23	0.04%		
		Behaviours	honest	22	0.04%	0.10%	
			collaborative	14	0.03%		
			collective	14	0.03%		
		Innovative Commitment to change	opportunity	54	0.10%	0.34%	
			opportunities	20	0.04%		
			commitment	42	0.08%		
			innovation	32	0.06%		
			investment	32	0.06%		
		Communication	Communication /s	28	0.06%	0.06%	

Finding #8: change management. One of the largest positive impacts for SDG measurement is about engaging, communicating and energising the delivery teams. This involves the internal teams and suppliers. The millennials have a key role to help build and sustain this change momentum.

6.6.3.6 Performance Management

The "performance management" node had the highest level of incidence (n = 82) of relevant statements coded from the 40 participants (using the NVivo software).

In terms of key word usage, this thematic, shown in Table 20, tracked “targets”, “measuring”, “performance management”, “quantitative”, “metrics”, “qualitative” and “contribution”. In total, they were used 1003 times across the 40 interviews, which equates to once every 50 words and represents the most referenced thematic.

The highest frequency of coding on NVivo was using the node for “what to measure”, reflecting the importance of this thematic. There were many references to what is measured, and the general theme was that the selection of targets becomes critical in a business environment that is already awash with data collection. Many asked whether they should collect quantitative data or qualitative and also asked what the balance between too little data collection and too much is. Almost all participants accepted that this was an extremely difficult area to resolve and that there were no easy answers. For example, Participant 34 stated: “*I think we are quite confused. It sounds like we are much more advanced than we are in the way we monitor, report and evaluate. Most of our work is about getting the basics right and ensuring we are complying with legal requirements—getting stuff done. We know we need to do more work on understanding sustainability outcomes and how we can develop detailed KPIs that feed into that for measuring our impact. We do not have outcome frameworks in place yet*”.

There was a consistent recognition amongst those that had more advanced levels of SDG measurement process maturity (participants 3, 19 and 20) that you had to start by selecting a manageable number of goals (from 17) and targets (from 169). This was explained by Participant 31, who said: “*It is an enormous challenge. I think, out of those 232, the fact that you found 20 that can be measured is actually pretty good if I think about the magnitude of the problem*”. Amongst the nine participants that were at the “early processes in place” stage, most were trying to establish hard metrics that could be quantified, such as Participant 15: “*We want hard targets to test our performance. Generally, as a business, qualitative is not very compelling. When we set up our strategy, we did some serious baselining to get some better referenced data*.”

Others were very open that they couldn't see any relevance or value in developing an SDG performance management framework for SDGs, such as Participant 34: “*We found that the SDGs were impacted by our work, some more than others, in terms of the goals and targets, but they are not particularly relevant to the* *work that we do so our priorities have been elsewhere*". There were a few of those that were in the 'early process maturity stage (2, 5, 6, 9, 35) who had similar views to Participant 16: "*Its fine for the senior leaders to talk about sustainability, responsible business and the metrics we want to measure - but getting that filtered down as a priority is challenging because at the project level, people are very busy delivering to time and cost and often the extra measurement targets appear to distract from this core focus of being profitable" and later added "all I'm saying is that it is great to have targets with great ambition and objectives and things like that you drive towards but in internally there is this ongoing challenge of making sure that it makes sense and adds value*". But in a contrary view, Participant 19 represented those that believed there would be value by measuring impact at project level: "*Being able to measure the contribution of individual projects to the SDGs – might be helpful but it's far from straightforward and what you measure depends on why you measure*."

The theme of adapting the SDG targets to have relevance to your own organisation, was also noted by Participant 5 (CEO), who also links the approach to millennials: "*it is best to set targets that mean something to your company and your people individually, rather than having generic targets which are enforced on you - actually setting a limited number means something to you as a business is the right way forward and of course the trouble is with people who set things they tend to want to measure and really don't buy into the longer game, so everyone should say - so we want to measure over a year or two and see a significant change so that we can all say "We've done that". And that's the problem with the target-based world. This is about actually you know what's the future generation - young people who are the new generation are a bit more wired up to it than those currently in leadership positions today. Maybe it will be quite different in 20 years' time because the emergent leaders coming through will get all this and want to do things differently*.

Some provided valuable challenge as to the important differentiation between contribution , versus attribution, such as Participant 19: "*It is about us as engineers understanding the contribution our projects are making to achieving the aspirations of the SDGs (contributing to the SDGs) - not just the goals but the targets. There will be no one-size fits all, and a check list to say a project relates to a goal/target is far removed from a anything that meaningfully assesses impact*." This is further explored by Participant 27: "*using attribution-contribution seems to be a very helpful way of* *not claiming too much and therefore we evidence collection to substantiate whichever one you're going down is different levels of granularity. I think it will be wise to be able to talk about to what extent we are contributing to the wide impact and outcome captured by the SDGs. But we can talk more specifically about the attribution around the outputs and activities towards the SDGs".* At a strategic organisational level, Participant 27 placed emphasis on contribution: "*Our Strategy is called 'Our contribution"*. "*We have identified 5 SDGs that we feel we have an opportunity to have an impact and where we are already doing a lot in. These coincide with our business model and provide the best opportunity to demonstrate benefit and what we are doing to measure performance against those SDGs*". Participant 19, a global sustainable development leader, said: *"Being able to measure the contribution of individual projects to the SDGs – might be helpful but it's far from straightforward and what you measure depends on why you measure*." She also said,*"It is about us as engineers understanding the contribution our projects are making to achieving the aspirations of the SDGs (contributing to the SDGs) - not just the goals but the targets. There will be no one-size fits all, and a check list to say a project relates to a goal/target is far removed from a anything that meaningfully assesses impact."*

One of the key problems, mentioned earlier, is the level of complexity in measuring 169 SDG targets. It was frequently explained that this was too complicated for the construction sector, as stated by Participant 2: "*But the indicators are far too detailed and big and sometimes not applicable as well. Therefore, it is better to work at a higher level for the projects. I have more interest in the goals and not the indicators*".

The emphasis on quantifiable targets was countered by Participant 25: "*telling the story of the success against the sustainable development goals, as an example; a lot of the time, it cannot be quantified very easily and therefore telling the story around an outcome perhaps provides more impact and value than just putting a meaningless quantitative score against something*". This viewpoint was backed by Participant 2: "*In the beginning, I wanted quantification to have numbers that I can use to understand the measurement data. This created a big pushback because engineers tend to want perfect solutions. The assessment was causing some culture issues, so the qualitative aspects have been preserved but not the quantitative. So, we still look for the holy grail but, at this stage, we are going to produce stories. In future we would* *like more quantitative that can be assessed at corporate level*." This was also noted by Participant 27 who stated: "we need to *be able to tell a very compelling story but that's qualitative more than quantitative.*

A further area of research interest was on planning horizons. There was frequent reference to the need to think longer term. SDGs have targets and goals for 2030, but some of the participants discussed moving away from short term RoI (return on investment decisions) that were driven by economics only, to a longer term more balanced approach across environment and society issues. Hence the SDG were viewed as a good way to achieve this ambition, as discussed by Participant 14: "*a danger that when you look at those longer-term goals that we allow them to be longer term aims that sit off to one side somewhere and that we want to contribute to, but it's in addition to or on top of our day job*". Participant 3 put the same point slightly differently: "*it's not just about delivering a building, it's not just about delivering a renewable energy project, that is about every project that we do - It's how can we design it for the future and through that, that is supporting the SDGs as much as possible in a meaningful way*".

Table 20: Text analysis (NVivo) on key words' frequency: performance management.

Category	C-M-O	Sub-Category	Word	Count	f1 Word %	f2 Sub-Cat %	f3 Cat %
Performance Management	Mechanism	Targets and measuring	target	31	0.06%	1.36%	1.90%
			targets	208	0.39%		
			objectives	26	0.05%		
			indicators	76	0.14%		
			measure	142	0.27%		
			measuring	72	0.14%		
			measuring	72	0.14%		
			measurement	54	0.10%		
			measured	17	0.03%		
			measures	21	0.04%		
		Performance management - quantitative	management	83	0.16%	0.43%	
			performance	54	0.10%		
			metrics	46	0.09%		
			objectives	26	0.05%		
			quantitative	18	0.03%		
		Qualitative contribution	contribution	40	0.08%	0.11%	

Finding #9: select a few targets relevant to the construction organisation or project. Keep it simple and build knowledge progressively.

6.6.3.7 Project-to-Portfolio Levels

The “project-to-portfolio” node had the eighth highest level of incidence (n = 21) of relevant statements coded from the 40 participants (using the NVivo software). In terms of key word usage, this thematic (shown in Table 21) tracked “projects”, “programmes” and “portfolios”. In total, they were used 677 times across the 40 interviews, which equates to once every 80 words. There was wide recognition that the approach needed to be adapted but linked across the project, programme and portfolio levels, as noted by Participant 27: “*I think there is no 'one size fits all'. So, it will vary from programme to programme and be dependent on the country as well*”.

Special interest and importance were aligned with the node on “starting projects”. The preceding survey (Mansell et al., 2020) had not highlighted the importance of “starting projects well”. This node was added during the interviews stage because it was often referred to as the need to use the SDG lens at the “key investment decision point”, as noted by Participant 26: “*based on evidence frameworks, you can frame your project in a much better way to make sure the impact you get is maximized.*” The emphasis of getting stakeholder alignment was also mentioned by Participant 19: “*They want to demonstrate that their projects contribute to sustainability development goals and develop tools that make sure projects embed sustainability development at the outset, e.g., at their project inception phase*”. This was also extended to the importance of getting the project staff involved early, as noted by Participant 3: “*trying to get the delivery team involved in that as early as possible to think about what future Ready really means and how that can be played back to the client in a powerful way”.*

There were some, such as Participant 9, the head of sustainability for a utility company, who suggested that the SDG measurement had more relevance at the larger scale of programmes and at the organisational strategic level, represented by the portfolio office: “*Thus we do it more at programme and portfolio level and less at project level. So, we have a mapping process at the portfolio level and align across project and programme SDG targets*”.

Table 21: Text analysis (NVivo) on key words' frequency: projects-to-portfolios.

Category	C-M-O	Sub-Category	Word	Count	f1 Word %	f2 Sub-Cat %	f3 Cat %
Project; Programme; Portfolio	Context	Project Level	project	278	0.52%	0.87%	1.27%
			projects	185	0.35%		
		Programme Level	program	65	0.12%	0.35%	
			program	65	0.12%		
			programme	31	0.06%		
			programs	27	0.05%		
		Portfolio Level	portfolio	26	0.05%	0.05%	

> Finding #10: there was evidence that SDGs can be measured at all three levels: projects, programmes and portfolios. There was special value in using the SDG lens at the start of the project to help align stakeholders around the longer-term outcomes and impacts.

6.7 DISCUSSION

This section builds on the 10 core findings and culminates with generalisations across the three sub questions that guided the design of this research into SDG measurements. The three sub questions, as shown in Figure 51, stem from the primary research question: how do senior leaders in the construction sector rate and use global UN SDG goals for infrastructure investment decisions at the local level? The empirical research study, including aforementioned qualitative findings and supporting quantitative data, also allows an evaluation of the theory-driven propositions to be undertaken, which is provided according to the following areas of outcome, mechanism and context.

6.7.1 Outcome Discussion: What Are the Expected Outcomes of Successfully Using the SDG Measurement Mechanism?

The results showed that participants have the appetite and resolve to employ SDG measurement at business and project levels (Finding #2) in order to achieve outcomes that benefit people, the planet and profit. At the same time, they were frustrated by their inability to do so for reasons discussed in the following sections.

Most participants were optimistic that their organisation would achieve the broader outcomes by making SDG measurement more usable, consistent and verifiable across the construction sector, with increasing balance to their investment decisions across environment, economic and societal factors (Finding #1). There was almost unanimous conviction that the "ends" of achieving the desired "outcomes" was good for business (Finding #4). Some viewed this from a realist interpretation of the practical benefits of using the approach and language of SDG measurement to attract and retain millennial staff. Others made the additional connection with Porter and Kramer's Creating Shared Value (2019) theory, that suggests the outcomes from embedding SDG measurement in the delivery of their projects is good for business because, for example, the drive to address the carbon issues typically achieves improvements in efficiently and effectiveness.

Although the results emerged from a different thematic, some of the participants (2, 3, 17, 19, 20, 26 and 27) recognised the value of using Carol Weiss' seminal work (1972, 1983, 1995 and 2005) that uses the LogFrame and Theory of Change approach to take a stakeholder-centric perspective to assist the definition of longer-term impacts and outcomes. They acknowledged that this helps rebalance from an overemphasis on output definition, which is typically used in project management and too often judges success in terms of delivering the infrastructure asset to time, cost and scope (Finding #6).

6.7.2 Mechanism Discussion: What Design Criteria Enable the Mechanism (for Measuring SDG Impacts) to Achieve the Outcomes?

The views were consistent in stating that this was an important area for the construction sector to get right but that there was no best practice established for how to deliver an effective mechanism. Therefore, despite the strong support for its adoption, the depth of knowledge on SDGs was mostly superficial, and only 8% of the organisations interviewed self-assessed their SDG measurement processes as repeatable (Finding #2), with only a further 23% having processes at an "early adoption stage". The majority had not yet defined the SDG measurement processes. Unsurprisingly, there were many, especially at board and CEO level (with notable exceptions, such as 5, 7, 8 and 12), who showed some confusion in their knowledge of SDGs, sustainability and sustainable development. This was reflected in having relatively consistent and well-informed views on specialist areas, such as carbon management, but this was less evident in the details of what the SDGs represented.

The low level of uptake of the SDG measurements at the project level was attributed to the following reasons: (a) The complexity of the SDG framework, with the scale of ambition understandable at a high level but made excessively complicated when examining the 17 goals, 169 targets and 232 indicators; and, (b) The lack of adoption of SDGs by clients did not mandate SDG measurement (Finding #2).

In most participants' view, this had to be significantly simplified if the value of the SDGs were to be achieved (Finding #9). Otherwise, another reason for most organisations only having a very high level, somewhat superficial, view of SDG impacts on their projects, was because their clients did not mandate SDG measurement (Findings #2). There was therefore no incentive to dedicate finite resources on a complicated task that might not deliver them any value – indeed, it might even identify their organisation's weaknesses, which only a few explicitly opined was a good way of learning and developing. The current reality is that a high level approach could carry on. Some would view this as providing most of the reputational benefits of being able to tell a good story, but without similarly adopting – preparing and upholding - the business risk of being held to account for not setting sufficiently demanding targets, or worse, failing to achieve them.

A further design criterion that emerged, to enable the mechanism for measuring SDG impacts to achieve the outcomes, was the ability to find a golden thread from enterprise portfolio level to project level (Finding #10). This was most clearly explained by the participants that were most developed in their SDG measurement processes (2, 3, 11 and 20) but also included others who were actively developing SDG processes (8, 9, 14, 19, 27, 28 and 36). Whilst there was confidence in their self-assessed ability to achieve the golden thread from project to portfolio level (Finding #10), this was mostly not substantiated by any evidence (except 2, 3 and 11).

6.7.3 Context Discussion: What Issues Influence the Successful Use of an SDG Measurement Mechanism to Achieve the Desired Outcomes?

As part of the discussions on strengths and weaknesses, the participants identified a number of contextual issues that affected the likely success of the mechanism achieving the desired outcomes. These "context" issues included leadership (Finding #3), outcome-output definition (Finding #4), knowledge (Finding #5) and change management (Finding #8) capabilities. There were more optimistic discussions than pessimistic ones about the ways they could improve the contextual issues identified. However, a few had little incentive for, or perceived little value in, adding what they considered a burdensome task onto the shoulders of busy project managers.

As mentioned above, one of the most common explanations for the slow uptake of the SDGs, was related to their apparent complexity. The respondents insisted that the size of the task seemed unmanageable to some of the participants if the full 17 goals and 169 targets were all needing measurement. Some participants (12, 23, 25) linked the perceived complexity to the resulting 'voluntary' high resource costs of implementing a new performance framework. This relates to the earlier mentioned lack of client requirements that have not yet made SDG measurement mandatory, as noted above.

Given the seniority of the participants, it was not surprising that leadership and strategy was a dominant theme in discussions. This led to Finding #3, which states that strong leadership plays a significant part in inculcating SDG measurement as an ambition and core value into an organisation. This was most clearly stated by a senior executive (#11): "*Leadership is the most important critical success factor, both internally and externally, to align and galvanise our employees, our communities and the supply chain*". Others (2, 10, 17, 19 and 29), none of whom were CEOs or board members, stated that the strategic nature of organisational change had to be driven from the top, consistent with Kotter's change model (2012). There was recognition that, in reality, this meant that leaders at all levels were required as champions, which, for SDG measurement, needed to be aligned with success stories that would make sense to the target audience, expressed in their language and justifying "why" followed by explaining clearly "how".

A further 'Context' (of C-M-O) issue of unanimous agreement across the participants, was the role of learning and education (L&D) in increasing capability and specifically on understanding how to better share lessons on SDG measurement, for the good of all (Finding #5). It was positive to note that most participants shared examples of their organisation's efforts to increase knowledge and skills of employees, such as by learning how to define success in outcome terms (Finding #5). This appears to be aligned with other national studies on challenges of measuring sustainability, such as Hakkinen and Belloni (2011) who identified a shortfall in the knowledge levels of achieving 'green' construction and that these shortcomings limited Finnish construction practitioners from achieving the desired outcomes. As a CEO (#8) stated, "*one of my strategies in creating SDG awareness is through the increased emphasis on learning and development*". As discussed in the literature review, Haugh and Talwar (2010) have also indicated from their research into sustainability capability, that the use of action-learning on projects and the benefits from adoption of thorough 'lessons learning' as part of a comprehensive knowledge management system, could provide learning strategies for embedding SDG measurement in organisations. It was also noted by many (1, 3, 7, 12, 15, 23, 25, 27, 32) that investing in L&D, both in engineering courses as well as in on-the-job training, could better support the future generation of construction professionals to apply SDG measurement strategies. It was noted by a few, that this was especially important at the start of projects (Finding #10), when the investment decisions could be broadened by engaging the wider stakeholders on discussions on the longer-term SDG impacts desired.

Linking to the models developed by Kotter (2012) on leading change, the eighth finding was related to the contextual issue of change management (Finding #8). One of the most significant ways to influence the take-up of SDG measurement across organisations is engaging, communicating and energising the delivery teams. Research has shown that this is critical to achieving the right organisational cultures (Garavan & McGuire, 2010). This relates closely to the role of leaders as discussed above but also covers a number of other areas that participants shared. The issues raised included: the need for the 'talk' to be matched by the 'walk', with demonstrative and meaningful action; the need for honesty, to set targets that include the positive as well as the negative impacts, and the confidence to share the shortfall in performance, and learn from it; the essential need to capture the 'hearts and minds', especially of the millennials and across the genders; the positive use of innovation as a strategy to deliver the SDG goals, seeking new solutions to grand challenges; and, the clarity and consistency of communications across the stakeholders, to help galvanize and inspire. It was suggested that verifiable evidence of 'good news stories' would also help with communications and increase the likelihood of the change management succeeding.

The contextual issues identified above provide some indicative insights into broadening our understanding of factors that influence construction companies' decisions on whether to use SDGs as a lens for defining success and, if so, how they might use them effectively. Other studies delve deeper into construction sustainability benefits (Švajlenka et al., 2018) or, for example, the evaluation of modern methods of construction based on wood (as aligned to SDG 12 on responsible consumption and production) (Švajlenka, Kozlovská, 2018). Equally important areas that are not addressed in the thematics discussed above relate to green financing; some authors (Sergi et al., 2019) have provided insights into public–private partnerships as a mechanism for financing sustainable development. This highlights the breadth of relevant thematics and keeps the focus of this paper on just the restricted areas considered most important to the executives interviewed.

The resultant view, after applying the insights from the interviews, against the C-M-O 'Variables Framework' is shown below, as an illustrative subjective analysis based on the researcher's interpretation of the interviews' qualitative results:

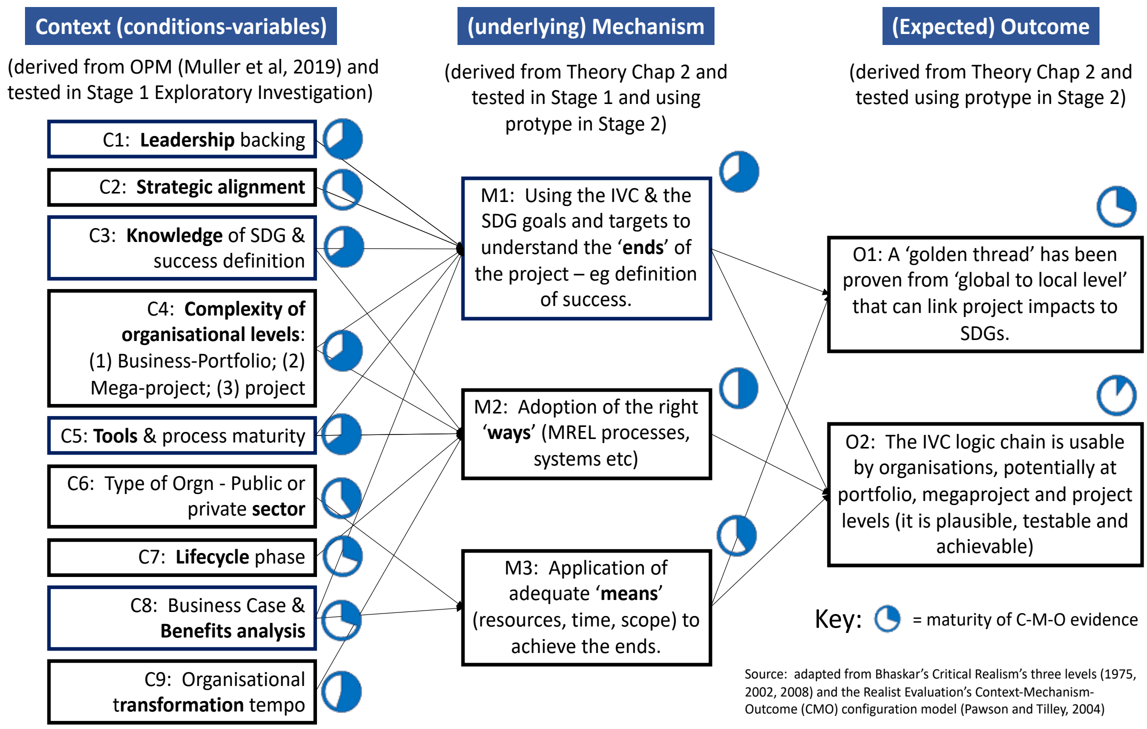


Figure 58. View 2 – Maturity of C-M-O evidence across variables post-interviews.

6.8 CHAPTER CONCLUSIONS AND DEVELOPMENT OF PROTOTYPE

This stage of the research study provided empirically grounded insights from the 40 senior leaders on their perceptions of how their organisations rated and used SDGs as a measurement lens. Building on the earlier results from the survey, discussed in the previous chapter, the 10 findings provided a rich and deep insight into answering the question of how to measure SDG performance on infrastructure projects. The empirical research also validated the theory-driven propositions that were synthesised from the literature. Furthermore, this stage of the research study identified that, whilst SDG measurement practices on infrastructure projects are embraced in theory, they are problematic in practice: rarely does action match rhetoric.

Although the 40 interviews described in the study specifically identified the primary stakeholder group as the senior executives of construction firms, there were a number of other stakeholders interviewed. This included: two senior government experts in the infrastructure sector; one financial advisor; one from the United Nations; and three from standards bodies (these 7 were part of the 40 participants). Consequently, the design of the study sought to include the considerations of wider stakeholders involved in project decision-making and this approach helped to ensure the broader relevance and applicability of the study to the infrastructure sector. The researcher had also consulted with the UK's Institution of Civil Engineers to ensure this broader perspective was adequately captured through the verification workshops with the MISI control group as illustrated in the Blog by the ICE Knowledge Manager from one of the workshops, (see Appendix 6).

One of the primary characteristics of the qualitative research is that the researcher "is the primary instrument for data collection and data analysis" (Merriam and Grenier 2019, p,13). This introduces a researcher's bias, that Singleton and Straits (2010) can be mitigated by becoming more self-aware when designing and implementing an interview data collection approach. If this can be actively addressed from the start by, for example: (1) asking the clear question, but allowing for the interviewee to develop their own line of thinking without shoe-horning them into specific areas; (2) interviewing an adequate sample, which was addressed by partnering with the ICE to benefit from accessing a senior level of executive that might not usually be available to a researcher; (3) sharing the proposed approach and questions, as well as the empirical evidence from the preceding survey (as published by the ICE for their 200th anniversary); (4) not misrepresenting the data results, by deploying best practice use of NVivo and ensuring logical and verifiable analysis. However, there is still a danger that, despite the strength of applying these 4 techniques, there is a remaining weakness since, unlike a survey or scientific experiment, the "human instrument" with all its shortcomings is not able to adjust to evolving changes. For example, the researcher allowed the interview questions to evolve in a free-flowing discussion (and followed the participants' train of thought when appropriate) when he detected a different line of enquiry. There is thus a need to apply caution to the potential hazard of bringing the researchers' own bias (Alvesson, 2003; Merriam and Tisdell, 2015; Merriam and Grenier, 2019). The researcher protected against this since "it is important to identify them [bias and subjectivity] and monitor them as to how they may be shaping the collection and interpretation of data" (Merriam and Grenier, 2019, p.13).

In regard to Stage 2 of this study, there was a lack of evidence given by participants on their ability to achieve the golden thread of SDG measurement from project to portfolio level (Finding #10) because, often, it was not available at any credible depth or backed up by verifiable evidence. This was an area to be tested in Stage Two to test whether aspirations to achieve this linkage are realistic. There was also the need for further research outside the UK since, while the findings from this study have broad global application due to the regional and global footprint of the participants' organisations, the complexities and challenges in some areas require further SDG measurement research.

The building of the evidence to respond to the study's propositions is shown below:

Table 22: Development (3rd) of stability of Propositions (changes since previous Chap in red)

Confidence in Evidence for Propositions	P1: Engineer's view of current MISI	P2: Organisational view of MISI	P3: 'Golden Thread' global - to - local	P4: Prototype Development
Theoretical Analysis	Not yet	Not yet	Very Low	Very Low
Survey Analysis	Moderate	Very Low	Very Low	Very Low
Interviews Analysis	Moderate	Moderate	Very Low	Very Low
Test 1: Golden Thread	Not yet	Not yet	Not yet	Not yet
Test 2: Case Study	Not yet	Not yet	Not yet	Not yet

(Note 1: The assessment of the quality of propositions' evidence is based on a qualitative formula designed by the Clinical Grading Working Group's British Medical Journal's study (GRADE, 2004). Full description and justification for this approach is shown in Table 8.)

Chapter 7: Triangulation of Results and development of Prototype

7.1 OUTLINE OF CHAPTER

This chapter captures the triangulation of results that informs the further development of the *SDG Impact Value Chain* (IVC) from an initial theoretical model into a more robust prototype, ready for testing. This is done through the iteration of the IVC theoretical model that was initially synthesised from Chapters 2 and 3, described more fully in Section 3.8. In this chapter, the IVC is jointly developed with a methodology, the SDGiPro©, that had been identified from the survey and interviews as a necessary extension to the IVC to support its implementation in 'active' projects. This early prototype is developed to a stage that is ready for testing in Test 1 (SDG 'Golden Thread') and Test 2 (in a water utility company context), discussed in Chapters 8 and 9 respectively.

7.1.1 Synthesising the initial theoretical model (*Impact Value Chain*) from literature

The initial IVC theoretical model, described in Section 3.8 and shown below in Figure 59 was based on four underpinning theoretical models, including: (1) the Theory of Change (Weiss, 1995 and Stein and Valters, 2012); (2) Creating Shared Value (Porter, 1985, 2011); (3) infrastructure systems approach (Hall et al., 2016, 2017; Thacker and Hall, 2018 and Thacker, et al., 2019); and (4) the Triple Bottom Line (Elkington, 1994, 2013, 2018 and 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. The IVC provides a new holistic method to potentially improve sustainability on projects and programmes by guiding decision makers in their investment choices through confidence that they link to specific SDG targets.

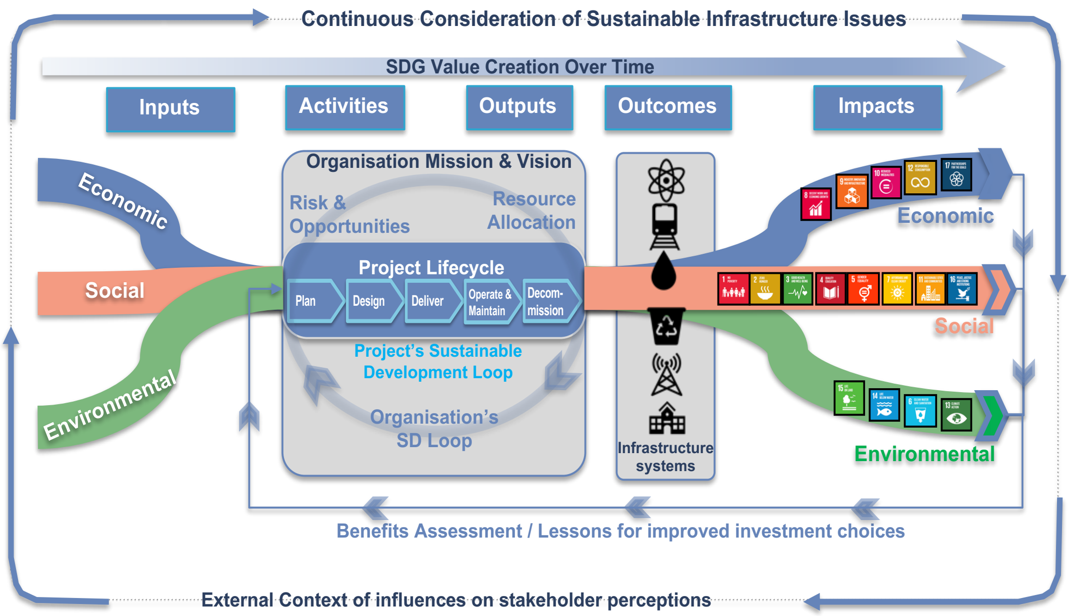


Figure 59: The Impact Value Chain (IVC) theoretical model, adapted from ICAS/IIRC's 'The Sustainable Development Goals, integrated thinking and the integrated report' (Adams, 2017).

7.1.2 Prototype Approach

For this research study the definition of a prototype is taken from a civil engineering study (Kim, 2019) into methodologies for developing early-stage solutions in a project design process. The study defines 'prototype' as both an '*original model of something that serves as a basis for other things*' and an '*early model that can be examined through tests to find a design solution*" (Dam and Siang, 2017). Importantly, the second description places emphasis on the designer's assuming-evolving-solving process in the design processes. The '*process involving the test-refinement-completion of designs using prototypes is called 'prototyping*' (Ulrich and Eppinger, 1995, 2004). Importantly, it not just about product design, it *'is also, and perhaps more importantly, a phase in a critical process*' (Lauff et al., 2018). Considering these viewpoints, this study adopts an adapted version of Kim's definition (2019): '*The MISI prototype is an early sample IVC model to test the concept and process of measuring SDG impacts at portfolio, megaproject and project levels, to act as a basis for further MISI learning'*.

7.1.3 Triangulation Approach

As discussed in Chapter 4, triangulation has been used extensively in qualitative and social research. The thinking behind triangulation was introduced by Norman Denzin (1970) in the 1970s when he developed the proposals by Webb et al. (1966)

and before them, Campbell and Fiske (1959). Denzin suggests (1970) it is a method that can improve the validity (extent to which a study accurately reflects or evaluates the concept or ideas being investigated) and credibility (trustworthiness and how believable a study is). Thus, the method design included an Explanatory Sequential Design (Creswell, 2015; Merriam and Grenier, 2019), followed by a triangulation of data to inform the development of the prototype, as shown below in Figure 60.

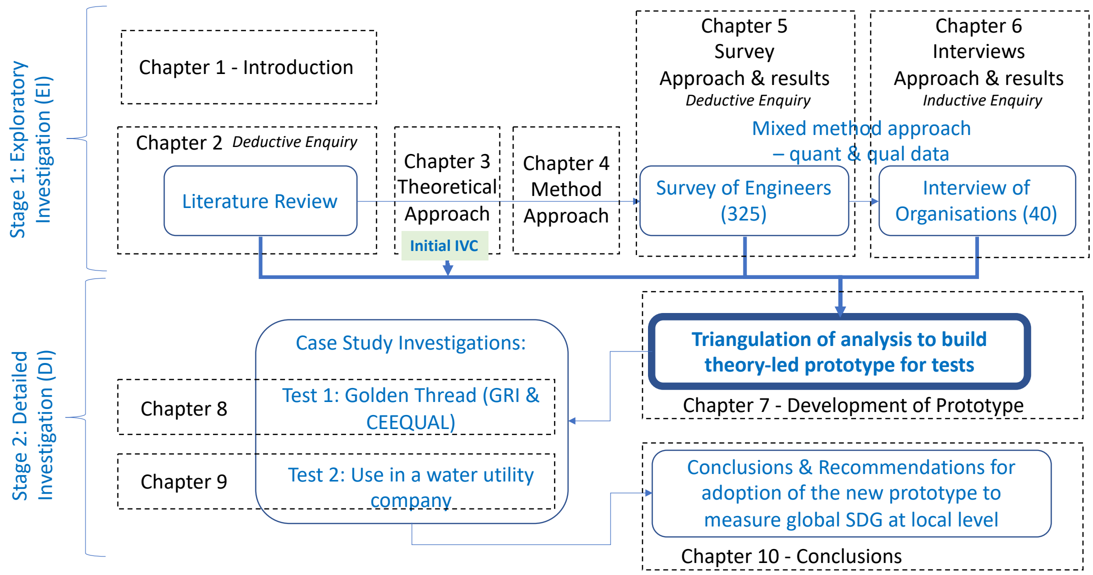


Figure 60: The Triangulation process to build the IVC Prototype.

7.2 TRIANGULATION OF RESULTS

The structuring of the triangulation evidence is aligned to the four concept areas that were derived from the outputs of the literature review and the theoretical chapter, shown in Section 3.8. These are:

- Concept 1 - The Theory of Change's Impact-Value Chain (IVC)
- Concept 2 - Delivery of Projects within an Organisational Structure
- Concept 3 – Infrastructure investments as 'system of systems'
- Concept 4 – Delivering Impact measured against the TBL/SDGs

7.2.1 Concept 1 - The Theory of Change's Impact-Value Chain (IVC)

7.2.1.1 Learnings from literature and theoretical review (Chapters 2 and 3):

- The first concept aligns the Theory of Change (ToC) with the Triple Bottom Line (TBL) as the fundamental basis of the theoretical IVC model. The ToC has its roots in the development of the Logical Framework Approach (Baccarini, 1999), also known as the 'LogFrame' or Goal Oriented Project Planning (GOPP) and Objectives Oriented Project Planning (OOPP) methods, in the development sector. This has been extensively tested, especially across international development projects, and is a basis for further prototype development.

7.2.1.2 Learnings from survey data (Chapter 5):

- The engineers surveyed (Chap 5, Finding #C3) highlighted the need for simple tools to measure project success using the SDGs, that should guide the design of the prototype.
- The survey noted (Chap 5, Finding #C2) that 'definition of success' and 'excessive focus on outputs instead of outcomes' (Chap 5, Finding #O2) were two of the five top challenges facing practical application of MISI. Thus, the IVC prototype should be developed with an emphasis of defining long-term goals and then map backward to identify necessary preconditions. In this way it should demonstrate the process of change by outlining causal linkages in an initiative, i.e., its shorter-term, intermediate, and longer-term outcomes. The IVC should enable the identified changes to be mapped as the 'outcomes pathway'.

7.2.1.3 Learnings from interviews (Chapters 6):

- There was almost unanimous conviction that the "ends" of achieving the desired "outcomes" was good for business (Chapter 6, Finding #4) and this should be messaged when seeking to get organisations to engage with the IVC prototype. This was supported by participants being optimistic that their organisation would achieve the broader outcomes by making SDG measurement more usable, consistent and verifiable across the construction sector, with increasing balance to their investment decisions across environment, economic and societal factors (Chapter 6, Finding #1).

- CEO's mentioned that a MISI tool needs to ensure strategic alignment, which aligns with use of the 'ends, ways, means' model using the Theory of Change.
- Whilst recognising the imperative of ensuring short-term commercial success when delivering project engagements for clients, all CEOs recognised the importance of defining outcomes and benefits from the start, which assumes an explicit need to plan for longer-term impacts. The IVC model should align with the existing benefits realisation processes.
- A number of the interview participants noted the importance of building a coalition of the 'willing' and that the alignment would be enhanced by using the IVC's ToC and TBL to demonstrate progress on the achievement of outcomes. In this way, evidence of success confirms the causal linkages and indicates that the initiative is effective in achieving its outcomes and SDG impacts.

7.2.2 Concept 2 - Delivery of Projects within an Organisational Structure

7.2.2.1 Learnings from literature and theoretical review (Chapters 2 and 3):

- The IVC prototype needed to further align (and be tested against) the project management development process, referred to as the project life cycle (Morris, 2013), which is typically based on a number of iterative and normative stages, such as: plan, design, deliver, operate/maintain, and decommission. The prototype should have utility at all stages, but especially at the initiation stage to align stakeholders and inform the development of the business case. Consideration should be given to testing the prototype against projects at different stages of design-delivery.
- The OPM model (Muller et al., 2019) provides useful insights to the organisational context and project context. The IVC prototype therefore needs to be flexible for the needs from portfolio, megaproject and project levels.
- The OPM model also notes the project lifecycle imperatives and thus the prototype needs to be adaptable to different stages of the project. For example, the early definition stage will not have full details of the activities, but the prototype should align to the Green Book Five Case Model so that it can be used across the public sector at the investment appraisal stage.

7.2.2.2 Learnings from survey data (Chapter 5):

- The survey results (Chap 5, Finding #M2) highlighted the need to enhance business skills of engineers to better define benefits and impacts. In this regard, it was suggested by a number of respondents that embedding business skills learning within core engineering educational programmes would help provide opportunities for meaningful improvements in the measurement of SDG performance on projects. This was also linked to the survey feedback that there was a need to move from excessive focus on outputs towards more emphasis being placed on outputs-outcomes. The prototype should therefore also include the need for iteratively building knowledge within IVC teams to ensure sufficient foundation busines skills. This would include ensuring a minimum level of knowledge on SDGs as well as, for example, the capability to accurately define and measure benefits. This learning from the survey data is subsequently embedded within the SDGiPro illustrated in outline at Figure 61.
- The survey responses also showed that there is significant room for improvement on availability of 'fit for purpose' engineering tools and methodologies to measure SDGs. These results highlight the need for a new simple tool, which should be a design principle of the prototype.
- The survey also noted that measurement of SDG performance should accommodate the requirements at different organisational levels, namely portfolio, programme and project levels. The prototype should accommodate the flexibility of working across these hierarchies.

7.2.2.3 Learnings from interviews (Chapters 6):

- Most interviewees referred to the myriad of existing sustainability reporting frameworks available and that not all of these provided value to their organisations. Many referred to the inter and intra organisational boundaries, where each organisation has its own sustainability reporting requirements as part of an annual reporting cycle. The testing of the prototype should therefore not be viewed as "yet another" reporting mechanism that is loaded onto already stressed project managers, but instead, be seen as a way of providing global credibility and clarity of purpose when using the IVC to measure SDG impacts at organisational level. The tests in the following two chapters explicitly sought to determine the opportunity of using the IVC at the organisational-portfolio level.

- A further prototype design criterion that emerged from the interviews, to enable the mechanism for measuring SDG impacts to achieve the outcomes, was the ability to find a golden thread from enterprise portfolio level to project level (Chap 6, Finding #10). This was most clearly explained by the participants that were most developed in their SDG measurement processes (2, 3, 11 and 20) but also included others who were actively developing SDG processes (8, 9, 14, 19, 27, 28 and 36). This could be done by choosing the Global Reporting Initiative as one framework to test for the 'Golden Thread' in Test 1, and secondly, to select an established sustainability champion at an organisational level for Test 2. However, in regard to testing the prototype, there was a lack of evidence given by interview participants on their ability to achieve the golden thread of SDG measurement from project to portfolio level (Chap 6, Finding #10) because, often, it was not available at any credible depth or backed up by verifiable evidence. It was therefore proposed that this was an area to be tested in Test 1 (Chap 8) to assess whether aspirations to achieve this linkage were realistic.

7.2.3 Concept 3 – Infrastructure investments as 'system of systems'

7.2.3.1 Learnings from literature and theoretical review (Chapters 2 and 3):

- The prototype should emphasise the concept of a system of systems in recognition that infrastructure projects in the built environment are more than the 'sum of their parts'. This can be achieved by highlighting the right-hand side of the ToC value chain that focuses on outcomes and impacts. In this way, the prototype could support organisations to plan in a more cohesive and systems-led way, which ultimately seeks to better manage the inherent inter and intra organisational complexities and boundary management issues.

7.2.3.2 Learnings from survey data (Chapter 5):

- The survey results (Chap 5, Finding #O2) indicated that there was strong belief that the choice of a career in engineering, was determined by a desire to provide a service to society. This was tested with relative weightings of priority goals – commercial or for broader societal or environmental goals, as defined by

Creating Shared Value. The millennials were particularly strong in their desire to link engineering projects to SDGs. Thus, the prototype should enable a clearer alignment with delivering a construction 'system' that can be linked to broader TBL thematics, including using the SDG as icons to define that wider purpose, since they have strong resonance with millennials.

7.2.3.3 Learnings from interviews (Chapters 6):

- Concept 3 challenges the traditional understanding of infrastructure as stand-alone physical assets and the interviewees frequently (>50%) referred to the wider goals of the assets, and that this required a new way of thinking. Of note were three megaproject CEOs, who had harnessed a systems approach to delivery, who all stated they were champions of linking their projects to SDGs. The prototype could therefore add value to existing system integration tasks.
- Again, the megaproject leaders were consistent in their view that there was a need to develop a MISI approach that focuses on the identification of interrelationships between components (i.e. sub-systems) of a system. The immediate design and testing of the prototype should include the steps to better understand the sub-systems from the start, such as breaking down the carbon issues across stakeholders and especially across the supply chain. In this way, systems mapping can align some of the prototype IVC modelling. The prototype should be evolved in future research to understand how this can happen.
- The interviews highlighted the broad range of National Economic Infrastructure systems that they were involved with, such as: Water, Energy, Transport, Waste, and Telecommunications. The prototype should be flexible to work across all categories as well as the functions which the infrastructure system enables, such as: across healthcare services, transport services, and education services.

7.2.4 Concept 4 – Delivering SDG Impact measured against the TBL/SDGs

7.2.4.1 Learnings from literature and theoretical review (Chapters 2 and 3):

- The fourth concept aligns the TBL with SDGs and strengthens the composite IVC value chain. The IVC prototype should therefore provide a means '*to determine stakeholder's preferences and the trade-offs they choose to make* *given their scarce resources, or the value the marketplaces on an item*' (Porter, 1985).

- There was evidence from the literature review that the definitions of impact, outcomes and benefits are often confused. This was further confirmed in the survey and interviews. The IVC prototype should therefore explicitly define the different parts of the model and why a deeper understanding is necessary to ensure consistent use of the IVC tool. This supports the earlier recommendation to develop the SDGiPro alongside the IVC to help project teams have a sequential series of workshops to build knowledge across these areas.

7.2.4.2 Learnings from survey data (Chapter 5):

- The survey summary results noted that existing sustainability measurement at organisational and project levels is well established, and therefore, SDG measurement should be aligned to existing successful approaches, not created as an 'add-on' i.e., the organisational level will likely have different SDG imperatives and reporting requirements, such as using the GRI, from the project level, which might have limited capability and capacity to track too many targets and indicators. The prototype should therefore be seen to build on existing approaches, not as a replacement to existing sustainability and benefits management processes.

7.2.4.3 Learnings from interviews (Chapters 6):

- The results showed that interview participants have the appetite and resolve to employ SDG measurement at business and project levels (Finding #2) in order to achieve outcomes that benefit people, the planet and profit. This should be included as part of the communications to entice organisations to trial the IVC prototype.

- Many executives mentioned the need to articulate their contribution to society with improved focus on the ultimate societal SDG impact. For example, in a flooding project context, one executive explained that any MISI prototype should explicitly seek to understand their flood project systems' service to society by determining the causal link to the SDG impacts and use this as a coherent way to assess sustainability across the TBL of economic, social and environmental impact areas as well as SDG impacts. The interviewee stated that the prototype would thus be able to engage stakeholders in a more meaningful way that would likely improve positive engagement as well as raising contributory funds from them (such as local councils) when they were better informed of the societal value-add.

- As part of the interview discussions on strengths and weaknesses, the participants identified a number of contextual issues that affected the likely success of the prototype mechanism likelihood of achieving the desired outcomes. These "context" issues included: leadership (Chap 6, Finding #3): outcome-output definition (Finding #4); knowledge (Finding #5); and change management (Finding #8) capabilities. The latter would be a key consideration to test the IVC prototype's SDGiPro methodology and would need to be addressed if agreement from trial organisations was to be achieved.

7.3 ITERATION OF THE IVC BY INCLUDING A METHODOLOGY FOR ADOPTION

Whilst the triangulation of empirical evidence, shown above, has strengthened understanding of what the IVC design should incorporate, there was also a large amount of useful evidence that addressed the 'employability' of the IVC. As such, there was an obvious gap that needed filling – the design of a complementary methodology for using the IVC prototype model. Two areas of design focus emerged: the design of a simple framework that would allow project and portfolio teams to develop, in a workshop environment, a causal path using the IVC, to define the 'ends, ways and means' of their project's SDG impacts; and secondly, a broader methodology titled the '*SDG Impacts on Projects*', shortened to: SDGiPro© that would support the operational teams through a series of iterative steps, to build their knowledge on SDGs, definition of project success and other prerequisite capability areas (as emerged from the findings discussed above). These are discussed below.

7.3.1 Iteration of the IVC by simplification and 'baseline' model

Based on the feedback from the surveys and interviews, the prototype must be simple to use and ensure a clear causal link across the Theory of Change, showing a logical progression from inputs-activities-outputs-outcomes-impacts. Therefore, the IVC was developed further by designing a simple framework that would allow project and portfolio teams to develop, in a workshop environment, a causal path using the IVC, to define the 'ends, ways and means' of their project's SDG impacts

In practice, the TBL can be mapped against the five stages of the IVC as shown in Figure 29. The examples shown indicate that there are clear 'Theory of Change' patterns that build through the iterative stages and this can be linked directly to project and organisational level understanding of sustainability reporting.

Table 23: IVC table illustrating golden thread mapping of the TBL in a 'baseline' model.

	(a) Input	(b) Activity	(c) Output	(d) Outcome	(e) Impact
Economy	Finance/investment, insurance, risk contingency allocations, WLC analysis, stable government and noncorrupt financial context.	Job creation; income; wages; source, move and assemble materials; build iteratively through defined activities, such as early earthworks, and local and wider supply chain activity	Project completion to time/cost/scope—bridge, building, road, etc.; income; profit; taxes from in-project business and 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 and 12.
Social	People, social networks, cultural and technical knowledge, and listening and working with stakeholders.	Collaborative innovation, health and wellbeing, stakeholder engagement, skills and learning, working conditions, production activity and user engagement.	Asset's social utility, meeting stakeholders' objectives, individual and group learning, and reinforced community stakeholder groups.	Infrastructure enabled change across health, education, etc., e.g., reduced mortality; gender equality; social equity; justice and post-project knowledge sharing.	SDGs 1, 2, 3, 4, 5, 7 and 11.
Environment	Raw materials, land take, water, light, clean air, energy, planned land use and ecology ecosystem valuation assessment.	GHG emissions; pollution; noise and air quality and works' effects pre and during production, e.g., waste management, nitrogen, carbon dioxide and acidification levels.	Managed effects on completion of asset; replanted trees, etc.; improved local area; no net loss on eco system footprint and 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 and 15.

7.3.1.1 Development of the SDGiPro Methodology

Secondly, to support implementation of the IVC, a practical model was developed. This methodology, titled the '*SDG Impacts on Projects*', shortened to SDGiPro©, was aimed to support the project teams through a series of iterative steps, that would enable them to build their knowledge on SDGs, definition of project success and other prerequisite capability areas (as emerged from the findings discussed above). The outline description of the methodology, with three design principles, that has been fully developed separately (not fully described in this thesis for reasons of brevity) into a workable methodology, is discussed below.

- **SDGiPro Design Principle 1: Provide a sequential stepping-stone approach for accessing the MISI terminology and theories**. SDGiPro is a framework that provides the guidance needed to initiate systemic change in the planning, design and delivery of sustainable and resilient infrastructure. SDGiPro is a decision-making guide, not a set of prescriptive measures. SDGiPro provides a gateway to access the language of the United Nations SDGs. SDGiPro enables project teams to adapt the organisational SDG intent into relevant local SDG metrics for all types and sizes of projects to help users assess and measure the extent to which their project contributes to conditions of SDGs across the full range of social, economic, and environmental indicators.
- **SDGiPro Design Principle 2: Designed to enable the IVC to align with existing processes**. Fundamentally, SDGiPro is about supporting higher performance through more sustainable choices in infrastructure development. The methodology provides a flexible system of SDG criteria and performance objectives, aligned to existing business case and benefits management processes as well as existing sustainability tools such as CEEQUAL. This aids decision makers and helps project teams identify sustainable approaches during planning, design, and construction that will carry forward throughout the project's operations and maintenance and end-of-life phases. Using SDGiPro as a guidance tool, owners, communities, designers, contractors, and other stakeholders are able to collaborate to make more informed decisions about the sustainability of infrastructure.
- **SDGiPro Design Principle 3**: **Adaptable for portfolio, megaprojects and projects.** Community infrastructure development is subject to the resource constraints of multiple departments and agencies, each with different schedules, agendas, mandates, budget cycles, and funding sources. SDGiPro assesses not only individual project performance, but how well the infrastructure project contributes to the efficiency and long-term sustainability of the communities it serves. In this

way, SDGiPro not only asks, “Are we doing the project right?” but also, “Are we doing the right project?”

The design principles led to a methodology with five proposed steps that have emanated from the triangulation of empirical evidence. The framework is a proposed way to initiate the “right project” in the “right way” and with increased clarity of “Ends, Ways and Means” aligned to SDGs.

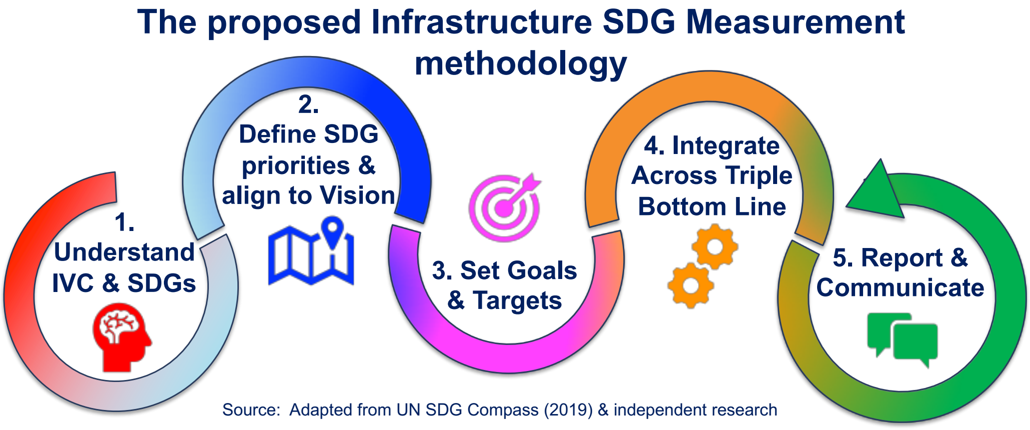


Figure 61: The proposed 5-step SDGiPro methodology.

The SDGiPro methodology included the development of a detailed set of workshops that are summarised below:

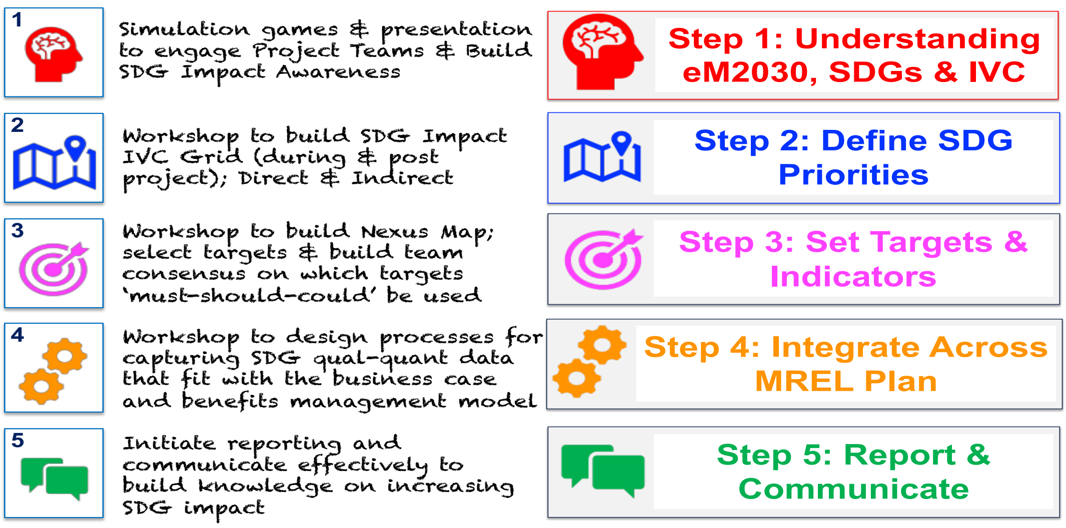


Figure 62: The SDGiPro iterative workshops.

7.4 CHAPTER CONCLUSIONS

This chapter has summarised research into the development of a prototype from the triangulation of data from Stage One Exploratory Design. This has led to the IVC being jointly developed with a methodology, the SDGiPro©, that had been identified from the survey and interviews as a necessary extension to the IVC to support its implementation in 'active' projects. This evolution of the MISI IVC tool meant that the early IVC prototype had been developed to a stage that was ready for testing in Test 1 (SDG 'Golden Thread') and Test 2 (in a water utility company context), discussed in Chapters 8 and 9 respectively. It should be noted that 'test' is actually a 'demonstration', since full validation testing is required prior to building a digitised version of the IVC that would have broader utility across the sector.

The further strengthening of Proposition 4 is shown in the table below.

Table 24: Development of stability of Propositions' Results (changes since previous Chap in red)

Confidence in Evidence for Propositions	P1: Engineer's view of current MISI	P2: Organisational view of MISI	P3: 'Golden Thread' global - to - local	P4: Prototype Development
Theoretical Analysis	Not yet	Not yet	Very Low	Very Low
Survey Analysis	Moderate	Very Low	Very Low	Very Low
Interviews Analysis	High	Moderate	Very Low	Moderate
Test 1: Golden Thread	Not yet	Not yet	Not yet	Not yet
Test 2: Case Study	Not yet	Not yet	Not yet	n/a

(Note 1: The assessment of the quality of propositions' evidence is based on a qualitative formula designed by the Clinical Grading Working Group's British Medical Journal's study (GRADE, 2004). Full description and justification for this approach is shown in Table 8.)

Chapter 8: Test 1: Is there a 'Golden Thread' from global SDG, through the Organisational Layer (portfolio), to local project level?

8.1 OUTLINE OF CHAPTER

This chapter discusses the first case study test, known as the 'Golden Thread' test. First, in Section 8.2, it places the investigation into the context of the broader aims of the Stage Two Detailed Investigation. In Section 8.3 it describes the context for the test and follows this by describing the 'Golden Thread' test's methodology in Section 8.4. The results are shared in Section 8.5 and this leads to the discussion of the implications that inform the research objectives and propositions.

8.2 STAGE TWO – DETAILED INVESTIGATION

The detailed research design was described in Chapter 4. This determined that the second stage of the investigation sought to build on Stage One by firstly triangulating the data with analysis from the literature review, the survey and the interviews, and secondly, to build a prototype model that could be tested. Through the iterative steps of Stage Two, shown in Figure 63 below, the purpose was to address a gap in knowledge through a series of test events that enabled the gradual deepening of understanding and thereby, to address the research question as well as the propositions.

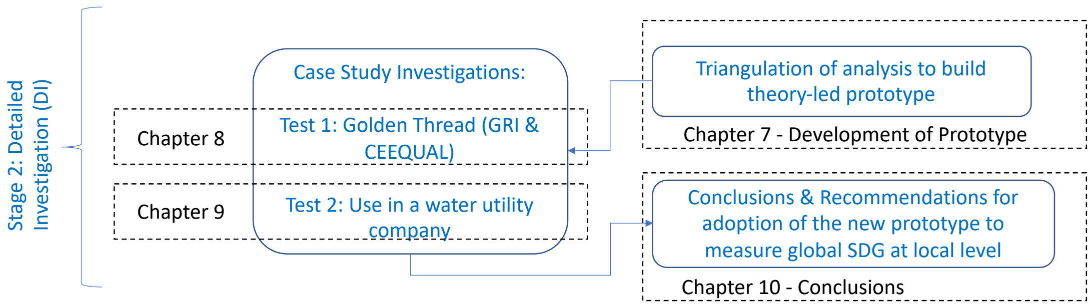


Figure 63: Detailed Investigation (DI) Flow Chart.

8.2.1 Context for the Test – Identifying a Golden Thread

In the search for a way to link 'bottom-up' project delivery and the 'top-down' Global Goals, empirical evidence was needed to substantiate the third proposition[9]. The intent was to identify a 'golden thread' between best practice sustainability reporting frameworks at the project level, with those at organisational level. In doing so, it aimed to establish whether there is sufficient linkage 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, which defines project success more widely across the 'Triple Bottom Line' (TBL) of economic, social and environmental outcomes and associated SDG impact.

8.3 METHODOLOGY FOR GOLDEN THREAD TEST APPROACH

In the search for a 'golden thread' between ground-level project delivery and the SDGs (to address the Research Objectives RO6 and RO7[10] and answer the Propositions 3 & 4[11]), two sub-tests were conducted (shown in Figure 64). Sub-Test 1.1 analysed whether the project-level sustainability reporting tool CEEQUAL (BRE, 2019), mapped to the TBL. Sub-Test 1.2 explored whether CEEQUAL could be mapped to SDG global level goals. Sub-Test 1.3 explored whether the organisational-level GRI approach (GRI, 2019) could be mapped to project-level (CEEQUAL) and this was followed by Test 1.4 that assessed linkage to SDG global level goals. If these tests proved positive, then there would be evidence to support the measurement of SDG at organisational and project levels. The logic-based flow of the tests is shown in Figure 64.

[9] Proposition 3: Current sustainability measurement at organisational and project levels can be used to demonstrate a 'golden thread' from 'global' SDG to 'local' portfolio and project levels.
[10] Research Objectives: RO6: To test whether a 'golden thread' of SDG measurement could be identified from global to local levels. RO7: To test whether the prototype could be validated with a case study organisation.
[11] Proposition 4: A MISI prototype can provide a plausible, testable and achievable logic chain for defining project and portfolio SDG impacts.

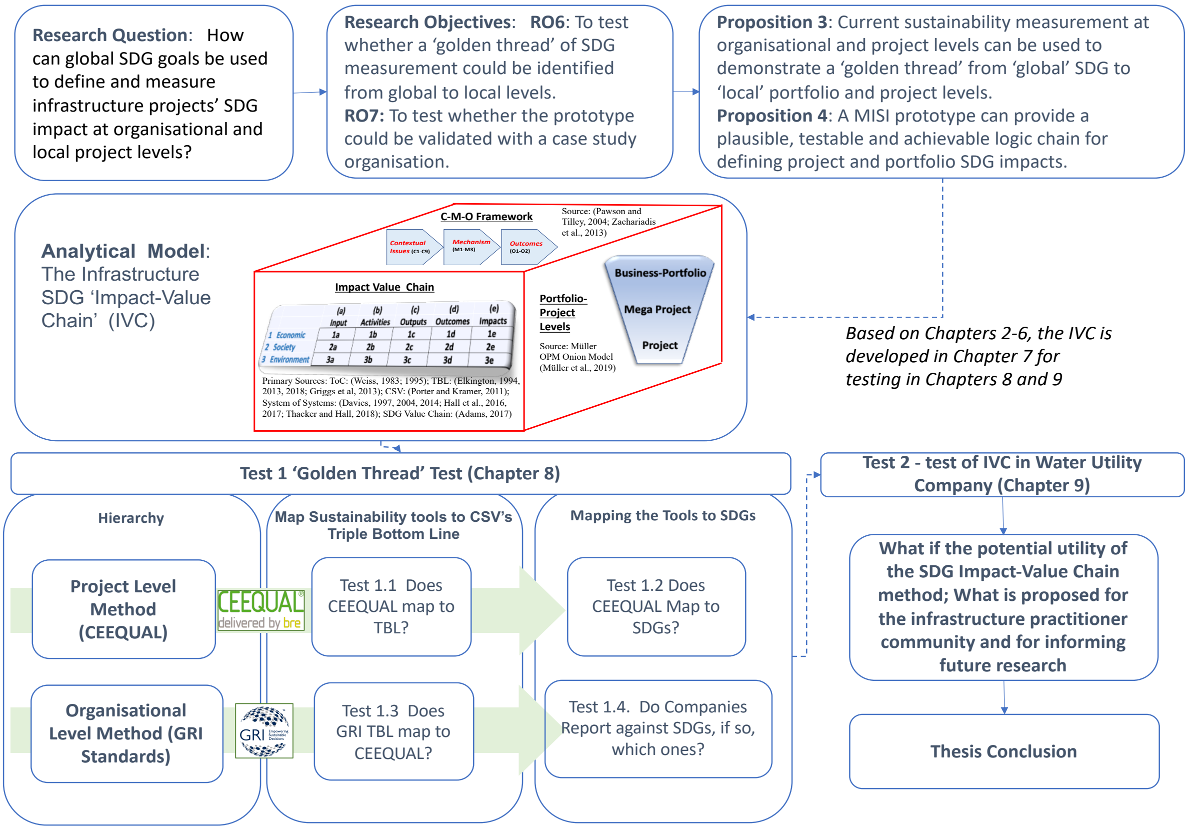


Figure 64: The IVC Testing Research Design.

Another view of the conceptual link that Test 1 was seeking to explore, across the TBL (economic, social, environmental) and the OPM model (project to portfolio) to national and global levels, is shown in Figure 65 below. The diagram shows a conceptual pathway of how an SDG measured at project level, might inform measurement at the portfolio, national and global levels.

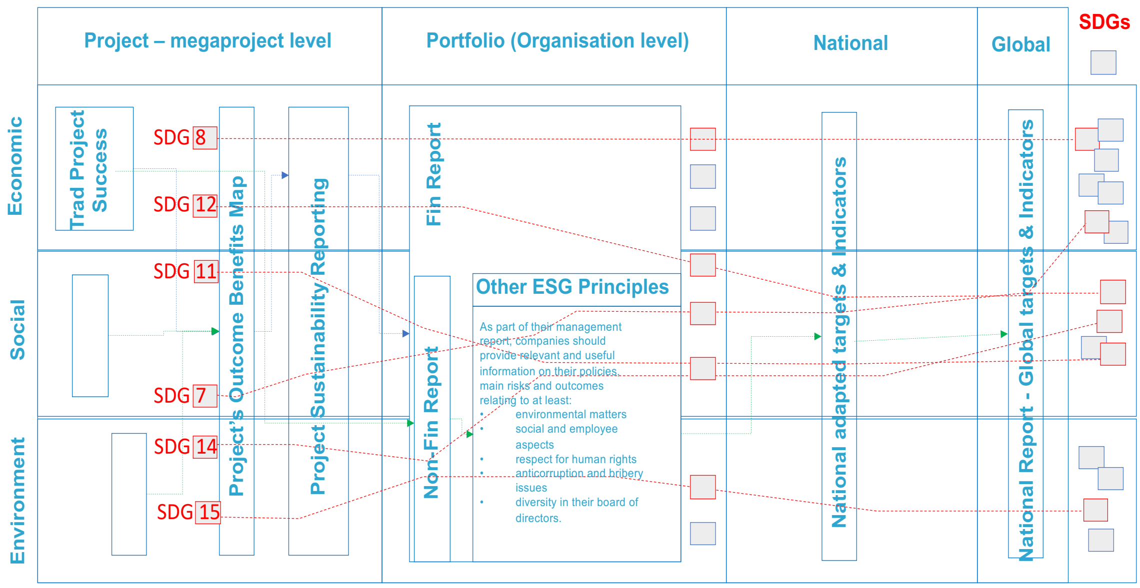


Figure 65: Conceptual map of potential 'golden thread' from local to global levels.

8.3.1 Selection of representative project and organisation level methods

To establish a potential golden thread from global to local, the study required two leading sustainability reporting methods, with international and national credibility. This led to the selection of CEEQUAL (which was compared with other global project measuring tools) and the Global Reporting Initiative's (GRI) global standard for organisational sustainability measurement. This stage of the research was conducted with the collaboration of both GRI and the Building Research Establishment (BRE), which is UK's leading centre of building science. BRE, as the owners of CEEQUAL, gave full access to their systems and standards to enable completion of the detailed text and process analysis of both standards in comparison to the SDG targets and indicators. A summary of some of the leading sustainability reporting frameworks from this evaluation of suitable tools, at organisational and project levels, is shown in Table 25 with a brief analysis of their explicit or implicit alignment with SDG measurement. It does not purport to provide a full in-depth comparison or discussion of the relative merits.

Table 25: Summary of leading infrastructure sustainability reporting tools/methods at organisational and project levels.

Tools and Methods	Relevance for the Research
1. Organisational level tools and methods. 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) and integrated reporting (De Villiers et al., 2014).	Based on analysis of the industry leading sustainability reporting frameworks (Corporate Reporting Dialogue, 2019, and PwC SDG Reporting Challenge, 2018), GRI was shown to be the most frequently used by leading companies. Indeed, of 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). For example, it was used by 6671 organisations in 2017 (GRI database, 2019) and 75% of Fortune 250 companies (KPMG, 2017) across 91 countries. Whilst the UN Global Compact has the "SDG Compass" methodology to support organisations to measure SDG impacts at

	subnational level, it remains at a high level and does not include any accepted standards for measurement of sub-national criteria. The case study expands on the challenge of trying to use the national level targets at organisational and project levels.
2. **Project level tools and methods**. Thirteen sustainability assessment methods were examined, including the following: CEEQUAL (UK & Ireland Projects/International Projects) (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 the 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), sustainable transportation appraisal rating system framework (STARS) (Sakamoto, 2014), IFC Performance Standards on Environmental and Social Sustainability, and World Bank Environmental and Social Framework.	The project-level sustainability frameworks were assessed against their ability to measure SDGs. Most of these were developed before the SDGs were agreed at the UN by the 193 states in 2015 and thus have no formal linkage to SDG measurement. Some, such as CEEQUAL, have started to link to both SDGs and to the GRI to establish a golden thread from project level to organisational level to national-global levels. However, although this research has confirmed there is the potential for the golden thread from project to global goals, there is only sporadic evidence of projects and organisations having achieved this requirement. Therefore, this confirms the knowledge gap and explains why the case study discussed in the next chapter (the choice of Anglian Water was motivated by their award of the UK's national prize in 2017 as "Sustainability Company of the Year").

8.3.2 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 CEEQUAL (BRE, 2019) was identified 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.

8.3.3 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.

8.3.4 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.

8.3.5 Selection of methods for each of the tests

Two tests were developed to address the research proposition. These required a variety of analytical methods, which are discussed below. 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 26.

Table 26: 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 launched in June 2019.	• New GRI Standards launched in July 2018.

8.3.6 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.

8.3.7 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 a 'reference group' convened and hosted by the Institution of Civil Engineers (including BRE, ICE, UNOPS and UCL collaborators – See Appendix 6 for the write-up by the ICE Knowledge Manager of one of these events). The aim of the review group was to construct 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.

8.3.8 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 (see Section 3.4). 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.

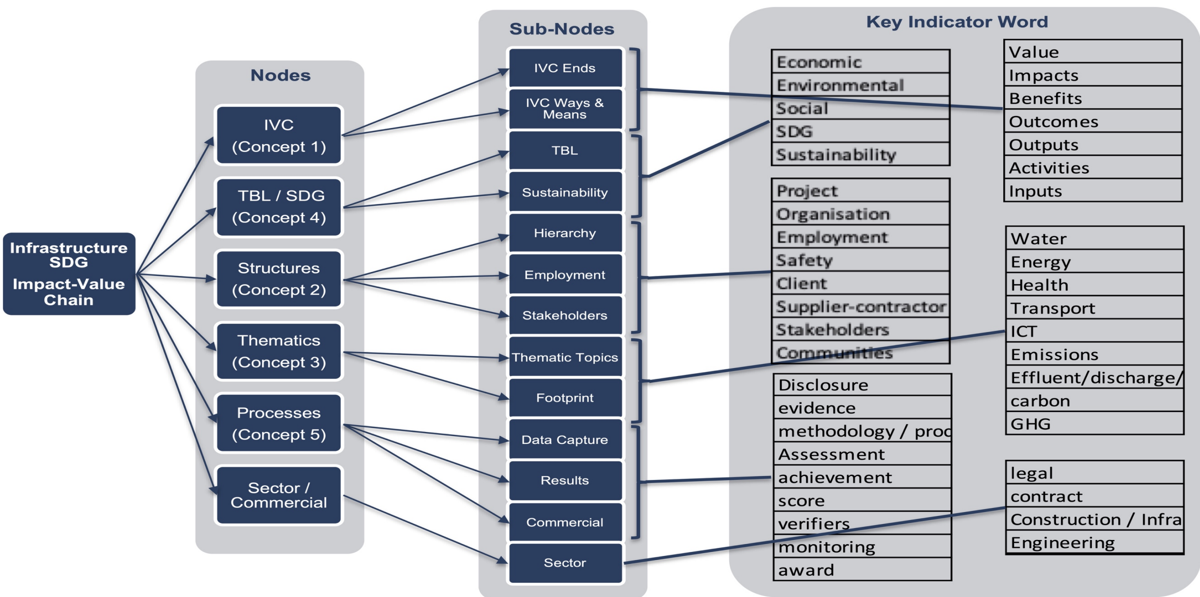


Figure 66: Tree map linking IVC four concepts to the Key Indicator Words via nodes and sub-nodes.

The tree map in Figure 66 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 Figure 66, across the two publications in Table 27.

Table 27: 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

Using these techniques, it was anticipated that the research in Test One would provide evidence as to whether the Analytical Model (embedded in Figure 64), 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.

8.4 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. The results are captured below.

8.4.1 Test 1.1. Does CEEQUAL map to GRI across the IVC thematics?

8.4.1.1 Part One of Test 1.1

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 (Figure 67) that is captured in bar chart format (Figure 68) to show the level of connectivity across the three TBL areas of Economic, Social, and Environment.

The data in Figure 68 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 in Figure 68.

CEEQUAL Category	CEEQUAL Issue	GRI 101	GRI 102		GRI 103	GRI 200 - Economic						GRI 300 - Environmental									GRI 400 - Social																				totals
		GRI 101: Foundation	GRI 102: General Disclosures		GRI 103 Report the Management Approach	201: Economic Performance	202: Market Presence	203: Indirect Economic Impacts	204: Procurement Practices	205: Anti-corruption	206: Anti-competitive Behavior	301: Materials	302: Energy	303: Water and Effluents	304: Biodiversity	305: Emissions	306: Effluents and Waste	307: Environmental Compliance	308: Supplier Environmental Assessment		401: Employment	402: Labor/Management Relations	403: Occupational Health and Safety	404: Training and Education	405: Diversity and Equal Opportunity	406: Non-discrimination	407: Freedom of Association and Collective Bargaining	408: Child Labor	409: Forced or Compulsory Labor	410: Security Practices	411: Rights of Indigenous Peoples	412: Human Rights Assessment	413: Local Communities	414: Supplier Social Assessment	415: Public Policy	416: Customer Health and Safety	417: Marketing and Labeling	418: Customer Privacy	419: Socioeconomic Compliance		
Management	Sustainability leadership	1	1		1													1			1	1	1	1	1								1	1	1	1			1		14
	Sustainability management		1		1				1					1	1	1	1	1	1				1	1									1	1	1	1			1		16
	Responsible construction practices				1							1			1		1	1	1				1										1	1	1	1			1		12
Communities and stakeholders	Wider economic benefits				1	1		1	1												1			1	1	1							1	1					1		11
	Wider social benefits				1																1		1	1	1								1	1	1	1			1		10
	Consultation and engagement				1																	1											1								3
Resilience	Climate change adaptation				1	1		1											1																						4
	Flood risk							1						1																			1								3
Land use and ecology	Land use and value				1	1		1							1				1																						5
	Land contamination and remediation				1									1	1	1	1	1																		1					7
	Soil and vegetation management				1									1	1	1	1	1																		1					7
	Protection of biodiversity				1									1	1	1	1	1																		1					7
	Enhancement of biodiversity				1									1	1	1	1	1																		1					7
Resources	Whole life environmental impacts from resource use				1	1						1	1	1			1	1	1				1										1		1				1		12
	Water				1									1			1	1	1																						5
	Energy				1								1			1																									3
	Responsible sourcing of construction products				1				1			1					1	1	1																						6
	Circular use of construction products				1							1		1				1																							4
	Environmental impact of construction products				1							1				1	1	1	1														1								7
	Construction Waste Management				1									1			1	1	1																						5
Pollution	Air pollution / Noise and vibration / Light pollution				1			1								1		1	1				1										1			1			1		9
	Water Pollution				1			1						1				1	1				1										1			1			1		9
Landscape & heritage	Landscape & Impact				1			1				1		1	1			1	1				1										1			1			1		11
	Cultural heritage				1			1															1	1															1		5
Transport	Transport Networks				1	1		1								1			1				1										1			1			1		9
	Construction Logistics				1	1		1	1			1	1			1		1															1			1			1		11
																																									202
	totals	1	2	0	25	6	0	10	4	0	0	7	3	12	8	10	11	17	13	0	3	2	10	5	3	1	0	0	0	0	0	0	14	5	5	13	0	0	12	202	

Figure 67: High-level Analytical Matrix Mapping showing linkages between CEEQUAL Categories (y-axis) with GRI Materiality Topics (x-axis).

The chart shown in Figure 68 below, can be interpreted as: Y-axis shows the number of occurrences in CEEQUAL's 246 questions; On X-axis, the left (blue) indices are GRI 200 Economic Material Topics, middle (green) = GRI 300 Environmental, right (brown) = GRI 400 Social.

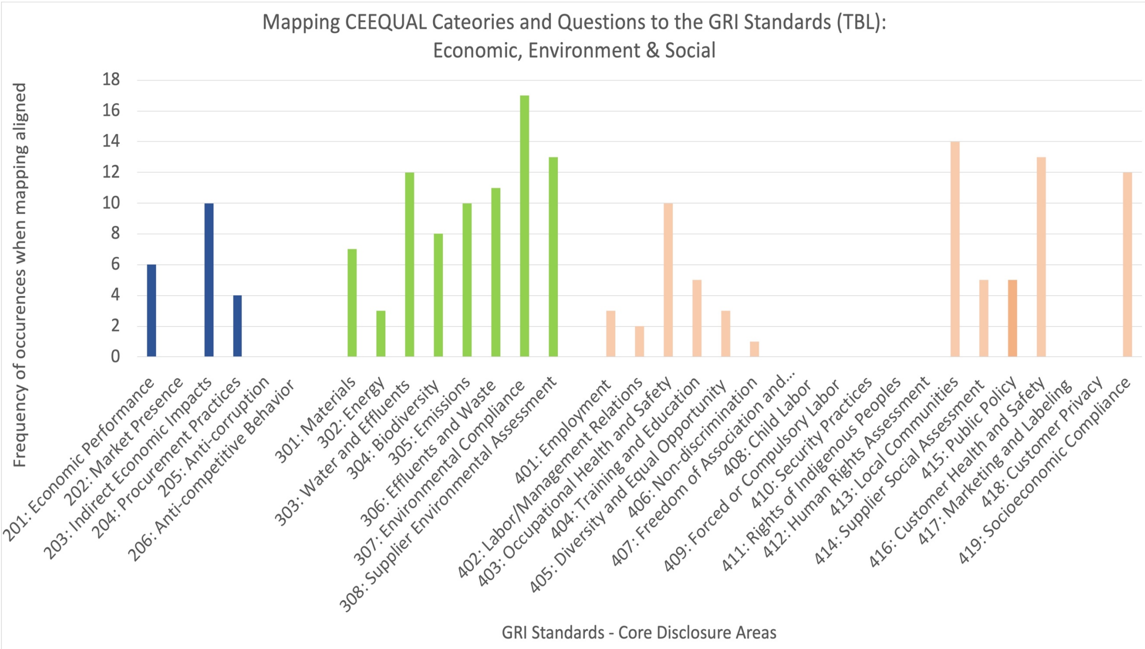


Figure 68: Bar Chart showing the instances of 'hot spots' where alignment is identified.

The results identified 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 review group's views) and needs further development to further strengthen the stability of the findings. This was done in part 2 of this test, using text analysis techniques.

8.4.1.2 Part Two of Test 1 (eg 1.2). 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 across CEEQUAL and GRI.

							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 Concept 2)	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
						Safety	331	0.21			25	0.05		
				Stakeholders	0.24	Client	0	0		0.22	289	0.38		0.26
						Supplier / contracto	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/	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 / proc	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 / Commercial	0.29	Commercial	0.17	legal	125	0.15	0.12	0.22	72	0.15	0.47	0.13
						contract	284	0.28			56	0.1		
				Sector	0.41	Construction / Infra	27	0.03		0.02	678	1.39		0.81
						Engineering	0	0			112	0.23		

Table 28: Data Analysis using NVivo: Nodal-Word linkages.

The table above is interpreted as follows: 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.

It should be noted that the percentage figures in the two columns in Table 28, 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:

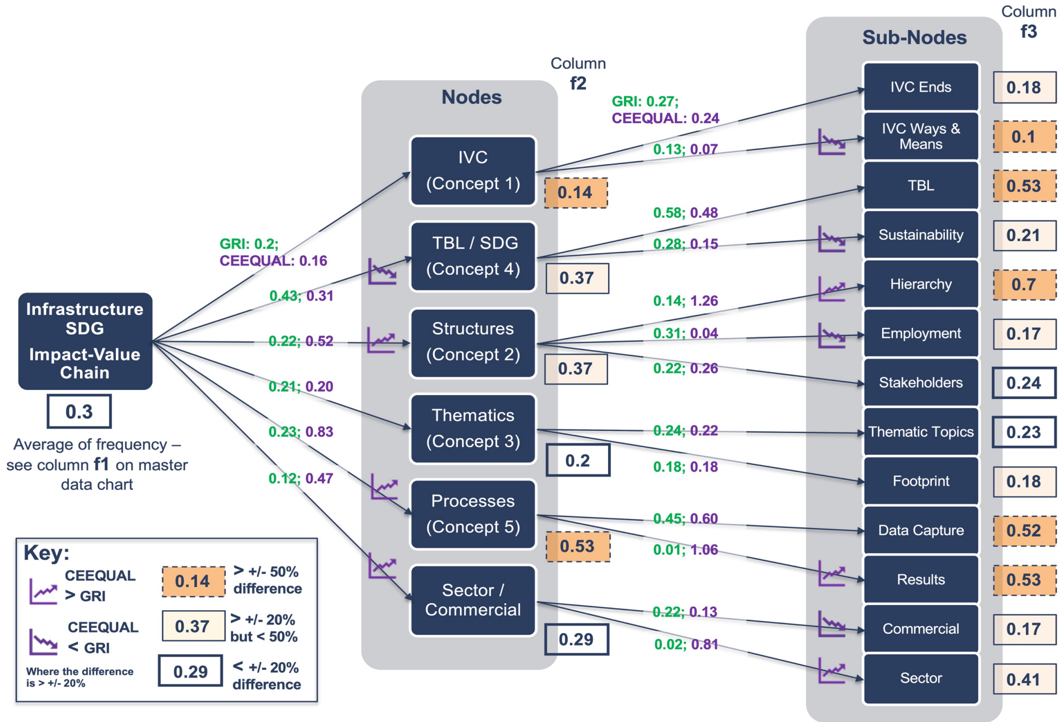


Figure 69: Data captured from NVivo analytical tool showing strength of connections across the 4 concepts in IVC from project level to organisational level (full data in Annex). For description of the columns, see Table 28 title.

The results shown in Table 29 below and Figure 69 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 29, with the corresponding findings indicated in bold '**F**', which are summarised in the table below:

Table 29: Key data results from the NVivo text analysis (See Appendix 10 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%. (**F1**)
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%). (**F2, F3**)	• 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.	• 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 and not what is being assessed	• CEEQUAL has a significantly greater interest in 'score', 'verify', 'monitor', 'award', 'assessment'. This indicates the strong focus on verifiable evidence. 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.	• Both have a similar level of emphasis on the capture of 'response' data. GRI uses the term 'disclosure' as primary term. The reports are 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. (**F4**)
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'. (**F5**)

8.4.2 Emerging issues from Test 1.1 (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 Figure 69. 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 Figure 66) across the two core documents. The diagram (Figure 69) shows the quantitative data that indicates six main similarities and differences between the two methodologies, which are as follows: 1) 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; 2) CEEQUAL's project-level sustainability reporting places more emphasis on environmental issues and social issues; 3) 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; 4) 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; 5) 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; 6) Both are intended to be voluntary and rely on the ‘carrot’ of highlighting good performers, instead of the ‘stick’ of reputational or fiscal penalties.

8.4.3 Findings from Test 1.1 (Parts 1&2 – see Table 29):

- 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.
- 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’. 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.
- 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.
- SDGs in both project level and organisational level reports need to be explicitly referenced.
- 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 drive the TBL sustainability decision-making process.
- 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.

- 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. 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.

8.4.4 Test 1.2. Does CEEQUAL map to SDGs?

The second sub-test explored whether CEEQUAL could be mapped to SDG global goals. The outputs from the full matrix mapping tool are held electronically by the researcher (available on request), but are shown at a high-level below in Figure 70. 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.

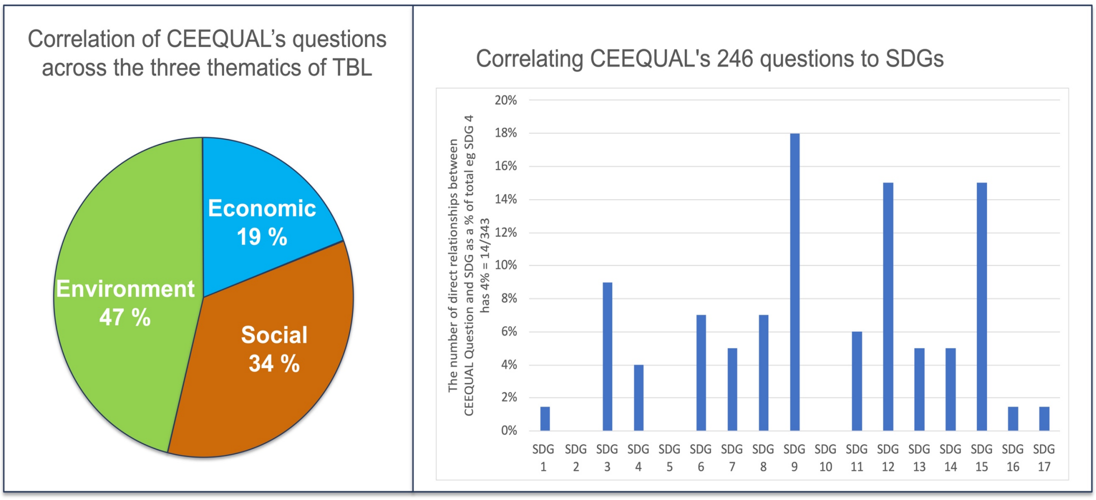


Figure 70: CEEQUAL's relative focus on TBL and across SDGs (full matrix analysis shown in Appendices).

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 Figure 71.

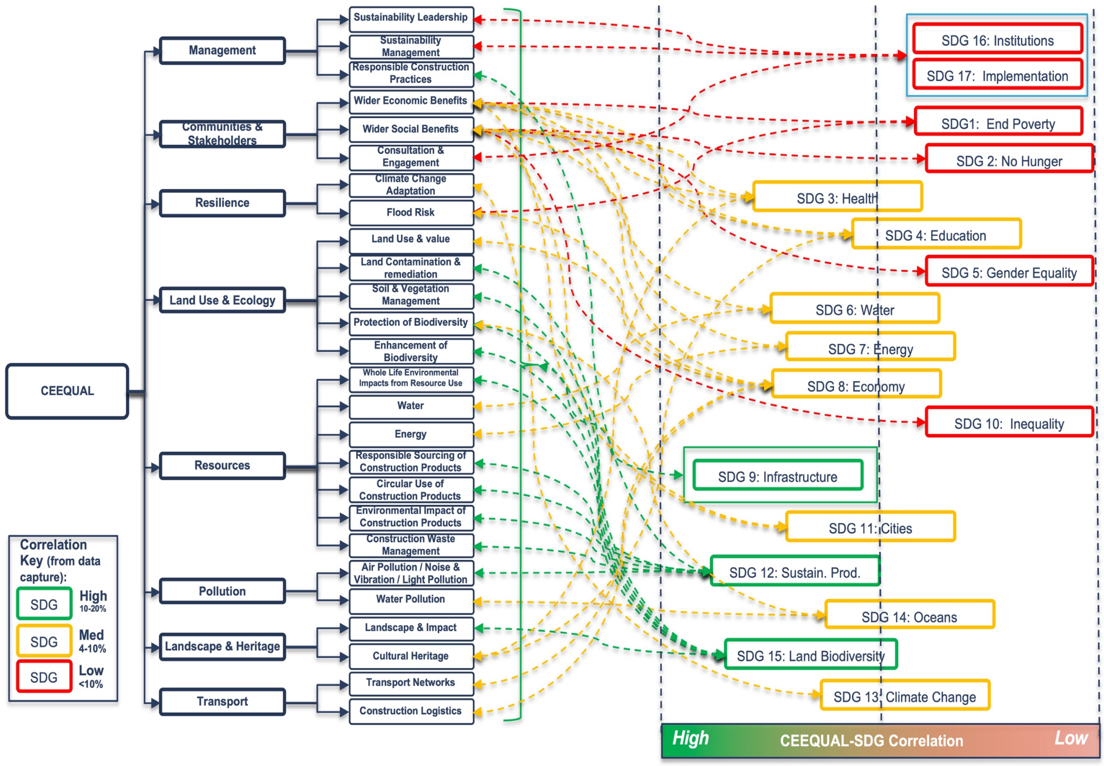


Figure 71: Systems mapping of connections between CEEQUAL and SDGs.

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 for SDG6, 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.

8.4.5 Limitations of the research

For this stage of the doctoral research, it is recognised that the analysis can only be considered as early exploratory research without definitive conclusions. However, it is used as a way of supporting the evidence gathering to respond to Research Objectives 6 and 7 as well as answering Propositions 3 and 4 (listed in Section 8.3). The specific limitations of the approach were as follows: the matrix mapping was only completed by the lead researcher and verified at a high level by a BRE Director and two senior academics (who supported this stage of the research study) 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.

8.4.6 Contribution to answering the Research Question, further research and potential applications

The aforementioned limitations suggest that this first Test in Stage Two of the overall MISI study has not provided definitive findings. However, it has helped provided evidence to respond to Research Objectives 6 and 7 as well as answering Propositions 3 and 4 (listed in Section 8.3). It has also established priorities for future research design. 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 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. This feeds initially into Test 2, the testing of the IVC with Anglian Water in Chapter 9, but also looks further ahead to the future research conducted with the Environment Agency and Tideway megaproject.

8.5 CONCLUSIONS

This chapter 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 'Test 1 of a Golden Thread' 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 was 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 Proposition 3, *Current sustainability measurement at organisational and project levels can be used to demonstrate a 'golden thread' from 'global' SDG to 'local' portfolio and project levels*, 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 next chapter uses a case study of a UK water utility company, Anglian Water, to demonstrate how the IVC process model can integrate the "triple bottom line" (Elkington, 1994, 2013, 2018, and Griggs et al., 2013) to ensure balanced definition of success across economic, environmental and social thematics. The emphasis is switched from "doing projects right" to "doing the right projects"; both are important, but the latter is critical. This is an explicit part of the IVC model, ensuring that short-term project success measures are balanced with post-project longer term outcomes and SDG strategic impact, which many (Morris, 2013, and Cooke-Davies, 2002 and 2007) have suggested are improved definitions of project success.

Table 30: Development (4th) of stability of Propositions (changes since previous Chap in red)

Confidence in Evidence for Propositions	P1: Engineer's view of current MISI	P2: Organisational view of MISI	P3: 'Golden Thread' global - to - local	P4: Prototype Development
Theoretical Analysis	Not yet	Not yet	Very Low	Very Low
Survey Analysis	Moderate	Very Low	Very Low	Very Low
Interviews Analysis	High	Moderate	Very Low	Very Low
Test 1: Golden Thread	High	Moderate	Moderate	Moderate
Test 2: Case Study	Not yet	Not yet	Not yet	Not yet

(Note 1: The assessment of the quality of propositions' evidence is based on a qualitative formula designed by the Clinical Grading Working Group's British Medical Journal's study (GRADE, 2004). Full description and justification for this approach is shown in Table 8.)

Chapter 9: Test 2: Case Study of IVC in Water Utility context

9.1 OUTLINE OF CHAPTER

This chapter outlines Test 2, the case study using the Impact Value Chain (IVC) in a water utility organisation. In Section 9.2 it introduces the context for the case by describing the identification of the water utility company, Anglian Water. It follows this in Sections 9.3 and 9.4 with the methodology and research design using the C-M-O mechanism, which includes the use of desk-level analysis of publicly available information and interviews with three leaders from the company to assess the potential practical use of the IVC. Following this, Section 9.5 outlines the findings stemming from the analysis to answer Proposition 4: *A MISI prototype can provide a plausible, testable and achievable logic chain for defining project and portfolio SDG impacts*.

9.1.1 Context for the Case Study – Using critical success factors (CSF)

This final part of the empirical testing builds on the previous development in Chapter 7 of an innovative infrastructure model, called the "Infrastructure SDG Impact-Value Chain" (IVC) to link local-level project delivery with global-level SDG impacts. It uses a case study of a water utility company to demonstrate how the IVC business model can integrate the 'triple bottom line' to ensure the balanced definition of success across economic, environmental and social thematic areas. The case study includes the selection of longer-term outcomes and strategic SDG impacts, which, it is suggested, are improved definitions of project success.

9.2 METHODOLOGY FOR CASE STUDY APPROACH

9.2.1 Using the Realist Evaluation Methodology to Structure the Research

As discussed in Chapters 3 and 4, the research study adopted the critical realism perspective of ideological philosophers, such as Bhaskar (1978), to inform the choice of the realist evaluation's context-mechanism-outcome (C-M-O) configuration (Pawson and Tilley, 2004) because it provides a strong framework for analysing engineers' perceptions of the context of SDG measurement as well as the potential outcome on redefining investment decisions to achieve broader SDG impacts.

The aim of this stage of the research was to demonstrate that, by using the IVC, the new model approach could be used to link an organisation’s strategic priorities with project level delivery using the SDGs. The validation exercise of the research was to review a leading organisation’s sustainability model, that already used the SDGs at goal (10 of the 17 were used) and target (35 of the 169 were used) levels, to assess whether the IVC would add clarity and structure to cascade the strategic goals down, through a portfolio office, to the project level. The assessment also considered the wider stakeholders’ views and what the application of the SDG framework had on their perception of value and practical usability. The choice of the organisation, Anglian Water, was based on it being one of the UK’s largest water utility companies. It is amongst the UK’s leading sustainability and sustainable development reporting pioneers (with early use of SDG targets) and was the winner of Business in the Community’s (BITC) Responsible Business of the Year Award in 2017. This recognised Anglian Water's ambitions, laid out in its “Love Every Drop” (of water) vision, which aimed to create a resilient environment that allowed sustainable growth and the ability to cope with the pressures of climate change.

The data for the case study was accessed by interviewing (1.5 h) a senior board-level member of the Anglian Water executive who, at the time, was the Director for Asset Management (DirAM). A second interview was held with the Head of Anglian Water’s Sustainability Management, as a further source of data and information. The latter worked alongside senior board-level members which added to his credibility as a data reference point to understand the emerging IVC. The DirAM was also the chair of the UK government’s Green Construction Board’s (2015) Infrastructure Working Group and has been a major sponsor and champion of the sustainable development programme across Anglian Water, as well as the infrastructure sector more generally, for the past 10 years. The DirAM provided publicly available documents (i.e., as a form of secondary research) to support the insights into the company’s pioneering work in sustainable development. A third interview was conducted with the head of the organisation’s supplier interface Joint Venture entity (the ‘@One Alliance’). This research was triangulated by evaluation of other forms of secondary data on the company, including information from the company’s website as well as related corporate documents and technical reports on the company’s approach to sustainable development in order to verify the data’s validity. Formal agreement for the review and the publication of the findings was agreed by the company in writing by DirAM and Anglian Water's Director of Brand and Communications.

9.3 RESULTS AND FINDINGS

9.3.1 Case Study Investigation: Anglian Water - Organisational Focus on Sustainable Development

The Anglian Water approach to sustainability and the SDGs is explained in their Annual Integrated Report (Anglian Water, 2018a). The report includes a description of their impact-value objectives (performance against outcomes) assessment, which correlates with the triple bottom line of the economic, social and environmental thematics. In summary, Anglian Water (AW) describe their TBL priorities as follows (Table 31).

Table 31: Anglian Water's performance against outcomes.

Anglian Water Outcomes	Objectives
1. Smart business. Innovating by exploring new ways to operate more sustainably and helping customers, business partners and employees to embrace our Love Every Drop strategy.	i. Resilient business. ii. Investing for tomorrow. iii. Fair charges, fair returns. iv. Our people: healthier, happier, safer.
2. Smart communities. Collaborating and engaging with customers, colleagues and business partners, and inspiring them to take positive steps towards achieving our vision for a sustainable future.	i. Positive impact on communities. ii. Safe, clean water. iii. Delighted customers.
3. Smart environment. Transforming behaviours by playing a leading role in reshaping how society values and uses water and reducing our combined impact on the world around us.	i. A smaller footprint. ii. Flourishing environment. iii. Supply meets demand.

These are shown below in the images from the *Annual Report* (Anglian Water, 2018a, pages, 24-25, 29) (Figure 72).

Figure 72: Anglian Water alignment of purpose-outcomes and SDGs (Anglian Water, 2018a). [Permission to re-use all graphics agreed by AW].

The following analysis of the case study is structured along the C-M-O 'Variables Framework'. The data is shown in the form of key quotes from the interviewees, supported by data gathered from open-source documents.

9.3.2 Context (#1): Strong Leadership. What is the Role of Leadership to Champion the SDG Impacts across the TBL?

Consistent with the survey results (Mansell, 2018), Anglian Water place a high priority on leadership to galvanise commitment to their corporate-level sustainability objectives. They achieve this through consistent and strong communications, both graphically, such as through their "Purpose Wheel" (Figure 73), and by the high-profile championing of their sustainable development approach by their board and executive.

Figure 73: Anglian Water's Purpose Wheel (Anglian Water, 2018a), aligned to the triple bottom line.

DirAM, a Director and Executive Board member at Anglian Water, observed (note: in future, all quotes from the interview are labelled as "DirAM" followed by the quotation) (a repeated quote from earlier): "*Leadership is the most important critical success factor, both internally and externally, to align and galvanise our employees, our communities and the supply chain. It was about getting us all to be more collaborative in finding novel, innovative ways of delivering sustainable solutions… It is about the leaders capturing the hearts and minds of the stakeholders to champion changed behaviours to achieve big, bold strategic outcomes.*"

In his view, it played an important part in Anglian Water becoming a sustainable development leader across the sector. DirAM: "*there are a number of reasons why we won Business in the Community's (BITC) Responsible Business of the Year Award in 2017—but a key part was that our CEO brought a very specific challenge back to the business having been inspired by a 'Seeing is Believing' visit, organised by BITC, to an area near the Olympic Park in London. The visit looked at how businesses were able to create opportunities and skills for those living in areas of high deprivation and low social mobility. The CEO's response was: 'how can we do something on a similar scale, in the region we serve, to make a real difference?'. This led to our hugely successful programme in Wisbech and helped us develop an approach that we have subsequently used on project work in Nepal alongside Water Aid*."

(Note: The Wisbech project, was a forerunner of the Lahan project in Nepal. Lahan was the first WaterAid project with significant engagement from the utilities' supply chain and became a beacon to demonstrate how such projects can be driven across Nepal and beyond.) The quote also reinforces Porter's theory of creating shared value (1985, 2011) because, in this example, there are tangible benefits for the business to be seen to be actively "putting back" into society.

He also notes the moral values that are implicit in the choice of making sustainable development a core business priority for Anglian Water. DirAM: "*a vital part of leadership is doing the right thing, just because it is the right thing to do, not because of a box-ticking exercise*". DirAM expands this to state the following: "*Our leadership was engaging the supply chain proactively to collaboratively change the way we thought about, and did, our business… We wanted the approach to become part of the way we jointly became leaders in delivering our businesses successfully… We wanted to establish meaningful change across the supply chain, and we recognised that, to do this, we had to develop long-term relationships; hence, we contracted on a five-, plus five-, plus five-year basis. This built longevity into our thinking and allowed true innovation to develop solutions to the bigger sustainable development issues across the environment—driving efficiency and effectiveness.*"

This was not necessarily an approach that was either quick or easy and it needed a tough commitment from the leadership, DirAM: "*It is 50% belief and 50% belligerence when you start something like this; that is, holding yourself and others to account. That is what I mean by belligerence. In other words, 'seeing it through'.*"

The core principles of governance (OECD, 2015) of accountability, responsibility and transparency were also noted; DirAM: "*a key part of the leadership is the ownership of the sustainable development strategy. It is also about accountability and having the resources to deliver the solution. That is why the 'Infrastructure Clients' are the single most important stakeholders in addressing sustainable development. If they 'own' and champion the solution, then the supply chain will follow… hence, leadership and procurement are the biggest elements of the recent Green Construction Board's 'Three Years On Report—Reducing Carbon Reduces Cost' report*" (Green Construction Board, 2015).

9.3.3 Outcomes (#2): Clarity of IVC Project Success Definition. Do Businesses Have a Clear Understanding of the Need to Separate Definitions of Success between "In-Project" Inputs/Activities/Outputs and "Post-Project" Outcomes and Impact?

In the Anglian Water Integrated Report 2018, (Anglian Water, 2018a, p.8), the CEO says: "*We are continuing to plan and to invest in protecting customers and the environment. This year saw the publication of our draft Water Resources Management Plan, which sets out how we propose to balance supply and demand in a fast-growing region over the next 25 years and to protect customers from severe water restrictions in a future drought*." The Annual Report highlights that Anglian Water explicitly assesses both the short-to-medium term economic factors that their investors value as well as the longer term strategic sustainable development impacts that are more aligned to SDG targets.

DirAM explains how Anglian Water used the overall "Love Every Drop" banner campaign to balance long-term and short-term priorities: "*In 2015 we refreshed our 'Love Every Drop' goals and aligned them with the Outcomes Wheel shown in the Annual Report. So, we thought long and hard about not just the goals that we created but how that fit with a set of longer-term outcomes in our region and what that would look like in terms of implementation. This was our way of meaningfully connecting the strategy with outcomes that our stakeholders recognised*."

It was also noted that Anglian Water uses simple and accessible language to explain their "Purpose Wheel" and its linkage to outcomes-impacts. This aligns with the IVC model and indicates a viable way of thinking "big and long" whilst managing the activities and outputs on a short-term basis to track progress.

9.3.4 Mechanism (#3): Prioritising SDG Goals Aligned to Strategic Vision. Do Businesses Have a Clearly Defined Strategy that Can Guide the Prioritisation of SDG Goals?

The Anglian Water approach aligns closely with the IVC model, since it also uses an "Ends, Ways, Means" logic similar to the Theory of Change concept (Weiss, 1995 and Stein and Valters, 2012). DirAM: "*you must start with the end in mind, even if you have not got a detailed routemap to deliver at every stage of the journey. Part of the mantra is to set big audacious goals and then adopt an attitude of 'I have started so I will finish' and, by the way, you never actually finish, because the end goal is moving; it is like you achieve one peak but realise it is a false horizon, and so you continue your climb to the next summit.*"

As well as the ten prioritised goals, Anglian Water had also prioritised 35 targets that are most easily measured at project level, shown below (Figure 74).

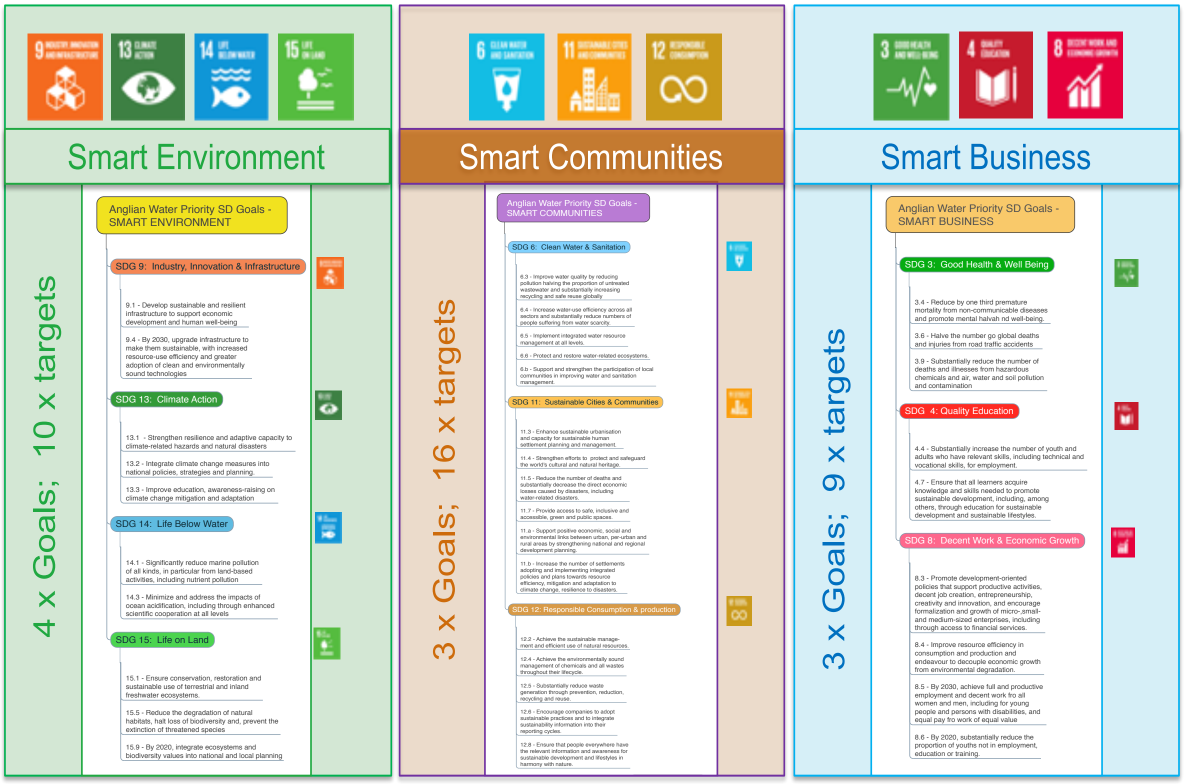


Figure 74: Anglian Water has three business priorities that are balanced across the triple bottom line (for illustration only).

The value of having clarity of the strategic ends is noted, albeit with a caution that the identification of targets for tracking performance must not become a "box-ticking" exercise that distorts clarity of outcomes; DirAM: "*if you actually begin with the end in mind of the outcome you are seeking and how you wire your DNA to achieve* *that, you are far more likely to achieve those outcomes, and in so doing the boxes get ticked. But if you predicate your thinking with thoughts about just filling the boxes, you have constrained yourself*."

Therefore, to overcome the box-ticking mentality, DirAM explained their approach: "*Anglian Water thought long and hard about its position in the region and how we contributed strategically as a major player in the region and we created the concept of "Love Every Drop" and, in essence, our own SDGs to align our strategy with local outcomes… We used the "Love Every Drop" goals to identify ambitious aspirations, which meant that our business had to think longer term*."

9.3.5 Mechanism (#4): Prioritisation of (a limited) Number of SDG Targets Relevant to the Infrastructure Project

The chart shown in Figure 74 illustrates the 35 targets selected by Anglian Water, which at first sight is impressive, but the interview identified that it is challenging to move beyond the rhetoric of great sounding qualitative statements. Therefore, it is important to agree and publish hard quantitative targets that the success of the organisation can be assessed against; DirAM: *"... so we nailed our colours to the mast and started reporting against those. One of them was to take 50% of the carbon out of the assets we build by 2015. It was the one that had a specific date on and a specific quantity, and I deliberately did that because I believed it and I was belligerent enough to drive it.… That is the one that, perhaps, out of all sustainability targets and goals, Anglian Water had the greatest recognition from and probably reflects the greatest change programme that has gone on across the whole of the supply chain*."

9.3.6 Mechanism (#5): Aligned Business Priorities/Integrate the Targets across the TBL. How Are the Project Success Criteria Balanced across the Triple Bottom Line - What Trade-Offs Are Made?

A representation of the linkage of the Anglian Water three TBL thematic outcomes (Elkington, 1994, 2013, 2018), aligned to their ten prioritised SDG goals, is shown below .

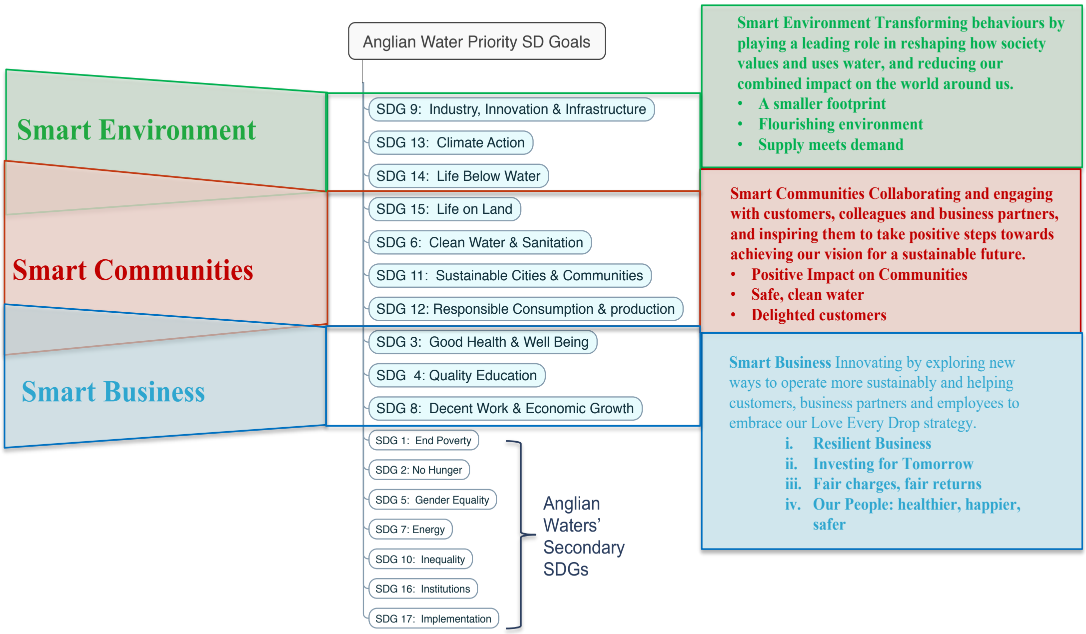


Figure 75: Anglian Water has three business priorities that are balanced across the triple bottom line.

In the Anglian Water integrated report of 2018 (AW, 2018a, p.9), the CEO, Peter Simpson, says: “*Since becoming Responsible Business of the Year, we have been working hard to show others how sustainability makes good business sense*”. This quote emphasizes the Anglian Water experience that aligns with the creating shared value (Porter, 1985 and 2011). It implies that the TBL (Griggs et al., 2013) can be balanced—a strategy that focuses on the environment and society, which can equally achieve economic success. When in harmony, real growth is delivered to the benefit of all, as shared by DirAM: “*For example, our approach to 'product lifecycle management' was learned from the aeronautical and automotive industry from 2004–2005 and this meant that we looked at the whole life costs, which not only ensured we were more outcomes focused, but, by the way, improved our productivity by 3% each year, year on year, highlighting that good sustainable development also made good business sense*”.

9.3.7 Mechanism (#6): Reporting and Communication. What is the Best Way to Share Data on SDG Progress, Internally and Externally?

It has already been noted that Anglian Water had a policy of thinking long-term, explaining their sustainable development approach in accessible language and also the need to uphold strong governance principles of accountability and transparency (OECD, 2015). This has led to a strong ethic of being held accountable for delivering meaningful change, including publishing their strategic objectives in quantifiable terms (such as the carbon figures noted in the paragraph above) as well as, equally importantly, the results; DirAM: "*learning from the likes of Marks and Spencer's Plan A, we realised you had better publish your sustainability plans and outcome targets so that you are kept honest in the process—there is very little point nailing your colours to the mast and then not living to the high expectations… so the message was that we must commit to do the things that matter to us. That is what gets people excited, because it really matters. We are tough on ourselves on reporting what happens, and this allows us to measure what impact we are having so that we can measure the benefit.*"

The theme of honesty and allowing stakeholders to hold the executive and board to account is a powerful lesson that also relates to measuring SDG impacts at project level; DirAM: "*But the point about turning your ambitious goals into reality, to avoid superficial statements, is that it is all recorded—it is published annually, which is an important part of defining where you are going. Driving towards it with no 'U' turns when some tough decisions have to be made. It is obvious that you have to make loads of tough decisions rather than duck them, and then recording your progress in an open and visible way helps keep you honest in that process*."

A cautionary note about communication was that the messaging should be kept simple and accessible; DirAM: "*We found that our campaign and collaborative working with partners had created a different conversation with different language. Ultimately, accessible language on meaningful outcomes is what people can buy into and this is what creates the momentum of changed behaviours… Through engagement and innovative solutions addressing the big problems, Wisbech is an example of working with the community to achieve meaningful long-term changes*."

9.4 OVERVIEW ANALYSIS OF ANGLIAN WATER'S PROJECTS SET AGAINST THE IVC FRAMEWORK

The research of MISI at Anglian Water was only envisaged as an initial demonstration of the utility of the IVC approach, rather than any kind of full-blown test. It provided insights that informed the full test that was subsequently completed with the Environment Agency and Thames Tideway megaproject from December 2019 to April 2020. Therefore, the discussion below should be viewed as providing 'guidance' not 'confirmation' of the IVC's potential use by portfolios and projects.

The reference to Anglian Water's Wisbech project in the previous quote provides a holistic test against the six critical success factors and a useful way to cap the case study analysis. Launched in January 2013 as part of Anglian Water's "Wisbech 2020" vision, the Wisbech project was chosen as part of this case study because data on its delivery are open source on the internet. It was delivered by Anglian Water with its partners as part of their commitment to make a long-term impact on the market town of Wisbech for more than the five years that the initial project covered. Located just 40 miles from Cambridge, UK, Wisbech faced many socio-economic challenges but also had potential for significant growth and development. The vision proposed a new garden town with 10,000 homes, bringing transport, education and health benefits to the town and surrounding region. By using this project as an example, Anglian Water wanted to assess whether a broad programme of social, economic and environmental change to improve the local communities' lives could be linked to the SDGs using the IVC.

The table below mirrors the formatting of the IVC table (Table 32) and has been updated with data from the Wisbech project (Anglian Water, 2018b). The simple steps to achieve the Wisbech-adapted IVC included: reading and analysis of the publicly available documentation of the Wisbech project, identification of key data across the IVC framework, cross-checking across authors to assess the credibility of interpretation and sharing the final table with Anglian Water to ensure the consistency and accuracy of project data. This provides an assessment as to whether projects could have both the "in-project" successes measured as well as the "post-project" outcomes and SDG impacts as defined in the Theory of Change (Weiss, 1995, and Stein and Valters, 2012). It was evident that it is easier to define quantifiable success criteria for the inputs-activity-outputs during the in-project phase because they are tangible and delivered as core delivery performance measures, such as time, cost and scope/quality. On the other hand, the outcome and impacts are typically delivered after the completion of the project and are more diffuse. Thus, the example from the Wisbech project shown below is not conclusive but gives indications that the IVC provides a useful framework to engage stakeholders on what project success looks like during and post-delivery. It should be noted that the Wisbech project is an outreach community programme inspired by HRH The Prince of Wales' "Seeing is Believing" initiative, which seeks to find ways to support marginalised communities. The SDGs therefore offer a framework to address the more diffuse outcomes and impacts that might not typically have been defined and measured using traditional project measurement approaches.

	Input	Activity	Output	Outcome	Impact
Economy	Seconded a Senior Operational Manager to Wisbech in 2013; agreed support from other supply chain partners to become involved in the project; this allowed the cost, expertise and effort to be shared across a broad range of partners.	Worked jointly with the local Fenland District Council to develop a longer term strategy beyond their existing 2020 Vision, which was thought to be too short-term to encompass the 'big, hairy, audacious' strategic goals that could achieve transformational change; building a business case for the 'Garden Town' that would attract investment and large transport infrastructure improvements.	Championing apprenticeships and training scheme with 20 trained and employed year on year; turn the community centre from a £30k pa loss making entity to a vital community hub fuelling future economic success; a confirmed lease and implemented the creation of the 'Jobs Fair' and the 'Jobs Café'; The campaigning body for getting rail back – now in the County Transport Plan.	Bills, affordability and profits to stimulate and sustain the local economy, especially those on lower incomes (bills have only increased by 10% since 1990). Viability of future rail and integrated transport system attracting more regional investment and raising local people's aspirations; Market Town proposal, with planning for over 10,000 new homes, providing 'scale of growth' confidence.	SDGs 8, 9, 10, 12
Social	Started by listening – to understand the local issues from the local community's perspective; Brought together senior leaders from 'The @One Alliance'; creating a collaborative multi-stakeholder approach; focused on building long-term sustainable relationships with the local community.	Collaborative innovation with the local community in open and honest talks; health & wellbeing; stakeholder engagement; skills and learning; working conditions; production activity; user engagement; keeping the local community at the heart of the project plans and delivery; worked with the College of West Anglia to train more mechanical and electrical engineers; designed and ran new courses; providing IT support from partners to raise	Providing a community centre (refurbishment of the Queen Mary Centre) that is the hub of employment opportunities; active STEM subjects engagement with schools; specifically focus efforts on helping those not in employment, education or training; untapped unused human resource; organised the BITC 'Big Connect' event align business connectors from across UK; a second phase for the Queen Mary community Centre to include	Achieving 'Business in the Community' outcomes such as regeneration; Building on the 'Seeing is Believing' community initiatives; Understanding the value of long-term thinking; Providing safe, clean and reliable water; Improve the town/regions standing as the 6th worst ranked town on social mobility index in UK; addressing the life expectancy that was 3 years less than in Cambridge.	SDGs 1,2,3,4,5,7,11

		aspirations of unemployed.	theatres and a music teaching centre.		
Environment	Raw materials; land take; water; light; clean air; energy; planned land use; ecology ecosystem valuation assessment.	Management plans for the flood risk, building resilience into engineering designs; using innovative modelling techniques developed by the Dutch government.	A commitment to protecting and restoring our wealth of wetland habitats. make a difference to rare and common species, be they in wet grasslands, open water, fens, or mires.	Build resilience to cope with future challenges. Protecting the environment, we live in; Through its Flourishing Environment Fund, helps environmental organisations deliver real benefits for nature.	SDGs 6,13,14,15

Table 32: Applying Anglian Water's Wisbech project initiative to the IVC grid with mapping of the TBL with the five stages of the IVC.

9.4.1 Policy Implications Derived from Analysis of Anglian Water's Use of the IVC Framework

There are a number of policy implications that emanate from the analysis of the Anglian Water case study. These are listed at both the organisational and project levels and involve multiple stakeholders, including clients, investors, suppliers and communities, who all benefit from the use of the derived models proposed in this study.

9.4.2 Organisational policy implications:

There is evidence that businesses identify value in the adoption of global SDG performance measurement at the local level. This is consistent with the theory of creating shared value (Porter, 1985, 2011) that identified a greater benefit to businesses than CSR, that is often perceived as being an add-on and not core to its success. The complexity of the global-national measurement framework makes measurement at subnational level challenging. The need for simplicity is important and examples of success, such as this case study, are helpful in galvanizing others to follow and share lessons learned. This is important for users of the models because the case study makes clear that some organisations are employing the language of SDG measurement but without a formalised methodology to do so. This makes it difficult to replicate because the ad-hoc nature of the measuring methodology used by Anglian Water does not easily support cross-sector comparisons using a common framework that would have facilitated further knowledge sharing and delivery improvements.

The SDG measurement approach can align with existing approaches to sustainability measurement. This offers efficiency of processes and systems if they can be linked. The case study gives confidence that existing reporting approaches to sustainability, such as CEEQUAL, are complementary to the proposed SDG measuring methodology. This highlights that the IVC can be adapted, such as by using language that "makes sense" to the local stakeholders and does not alienate existing project delivery teams who would not want an additional large reporting system mandated. The opportunity to align existing sustainability reporting metrics to SDG targets offers a valuable line of future research, going beyond what was achieved in Chapter 8.

There is evidence that businesses that already have a strong track record in sustainability measurement can readily adapt to the language and approach of using SDGs. Anglian Water had recently been awarded the UK's Sustainability Company of the Year, which meant that the case study interviews, and review of their documentation were conducted with a highly mature organisation that had a well-developed plan for delivering sustainable impacts. They also had a strong leadership team to champion the trialling of the SDG measurement approach. The bigger question remains how successful the less mature (in terms of SDG measurement journey) performing companies might be at addressing the complexities of SDG measurement. Again, this is an area for further study since that is where the majority of benefit might come from, by developing an approach that is easily replicated across the sector.

The 'Variables Framework' issues, such as leadership, are important. Strong leadership that is meaningfully engaged in championing the use of SDG measurement will be more likely to deliver tangible evidence of SDG impacts. This becomes a critical point as the strategic nature of organisational change has to be driven from the top (Kotter, 2012). There was recognition by the Anglian Water executive that, in reality, this meant that leaders at all levels were needed as champions, which, for SDG measurement, needed to be aligned with success stories that would make sense to the target audience written in their language and justifying "why" followed by explaining clearly "how".

9.4.3 Project level policy implications:

The effective use of SDG measurement at project level needs buy-in from both internal and external stakeholders. The engagement of suppliers is critical to ensure common focus on identifying what SDG success looks like and to work collaboratively to seek innovative solutions to deliver meaningful SDG success.

There are a number of mechanistic issues that become critical to SDG measurement success. These include: prioritising relevant targets and indicators (do not select too many); seeking to understand how the few selected goals and targets can have a simple indicator framework that allows the capture of reliable evidence; and ensuring that reporting and communicating is open, honest and timely, sharing both good news and bad news. There is also a need to continually learn and evolve and so build a better framework that achieves a more balanced investment decision across the TBL of people, profit and planet (Elkington, 1994, 2018, and Griggs et al., 2013).

9.5 CONCLUSIONS FROM THE TEST 2 CASE STUDY

The central investigation in the case study of Anglian Water was to test and validate whether the new infrastructure business model, called the "Infrastructure SDG Impact-Value Chain" (IVC), could link local-level project and organisational delivery with global-level strategic SDG impacts. The study used the "golden thread" of the TBL thematic areas (namely economic, social and environmental) (investigated in Chapter 8) to interrogate whether one of the UK's leading water utility companies, Anglian Water, was already delivering strategic sustainable development solutions that could be mapped to SDG targets. Although the research was conducted in the UK, the findings have potential broader applicability to other countries since it was observed that the SDGs are by nature a framework to be adopted by all countries and hence there is an international commonality of purpose in this regard. This is a valuable area of future research that could potentially engage with a number of construction firms with global footprints to compare the differences and similarities of measuring SDGs across and within different regional areas. For example, UNOPS (2018) research indicates that there are many contextual global issues that affect the use and measurement of SDGs but, while noting the differences, they suggest that all issues should have a consistent framework to enable cross-cutting comparisons.

The results of the case study investigation have indicated that there is a verifiable link across the IVC of activities-inputs-outputs during the "in-project" phase, connecting to the "post-project" outcomes and SDG impacts. A number of Anglian Water's projects were mapped to this schematic (although, for brevity, only one, Wisbech, is reproduced in this thesis) and this gave confidence that the approach could have wider applicability. Therefore, the results led to a proposed methodology for project leaders to use as a way of strategically aligning stakeholders on a common definition of success, linking tactical "in-project" success of outputs with the more strategic outcomes and SDG impacts "post-project". The methodology would ideally be used during the design phase of the project. The emphasis is switched from "doing projects right" to "doing the right projects". It includes the selection of longer-term outcomes and strategic SDG impacts, which, it is suggested, offer improved definitions of project success.

The Test 2 research case study has focused on a single case study in the UK and cannot, as stated earlier, be automatically extended to the entire water industry, either nationally or internationally. The methodology adopted, however, has potential to be used to evaluate multiple projects across different industry sectors. In this way, the results can thus provide insights for further research across the water industry and also potentially across other infrastructure sectors and geographical regions.

The final iteration of the maturity of evidence underpinning the response to the Propositions is shown below:

Table 33: Development (5^{th}) of stability of Propositions' Results (changes from this Chap in red)

Confidence in Evidence for Propositions	P1: Engineer's view of current MISI	P2: Organisational view of MISI	P3: 'Golden Thread' global – to – local	P4: Prototype Development
Theoretical Analysis	Not yet	Not yet	Very Low	Very Low
Survey Analysis	Moderate	Very Low	Very Low	Very Low
Interviews Analysis	High	Moderate	Very Low	Very Low
Test 1: Golden Thread	High	Moderate	Moderate	Moderate
Test 2: Case Study	High	Moderate-High	High	High

(Note 1: The assessment of the quality of propositions' evidence is based on a qualitative formula designed by the Clinical Grading Working Group's British Medical Journal's study (GRADE, 2004). Full description in shown in Table 8.)

In the next Chapter the thesis provides a holistic view across the full doctoral research study to describe the summary findings and implications for science and practitioners. It also describes the follow-on research approach, and emerging results, where the IVC has been extensively tested with collaborative partners including the Environment Agency, at portfolio and project levels, and with Thames Tideway at the megaproject level.

Chapter 10: Conclusions

10.1 OUTLINE OF CHAPTER

This chapter concludes the thesis. A summary of the research study is provided in Section 10.2 with a description of the high-level conclusions. Following the discussion of limitations in Section 10.3, the chapter provides recommendations in Section 10.4, including the implications of this research on the adaption of the Theory of Change for the future adoption of the proposed MISI approach using the IVC model and SDGiPro methodology. In Sections 10.5 and 10.6 it addresses potential value to both the scientific and practitioner communities and shares the emergent results from the collaboration with the Environment Agency, Thames Tideway and the UK Government's Infrastructure and Projects Authority (with UCL, ICE, BRE and UN Global Compact – all of which have their letters of impact support included as Appendices 17-23). Final thoughts from the researcher using reflexivity, provide concluding remarks to close the thesis.

10.2 SUMMARY OF THE RESEARCH STUDY RESULTS

The research was based on two main stages. The first stage was led by a systematic literature review that informed the research objectives, shared in Chapter 1, underpinning the research question. This helped to understand the contextual situation in which MISI mechanisms are used, and through empirical research, assess whether the current outcomes could be improved by the development of a theory-led prototype model that is workable at portfolio and project levels. The intent was that the IVC mechanism would provide a practical way to link from the local projects, through the organisational portfolio construct, to global SDG goals. The method chosen comprised a Sequential Explanatory Design (Creswell, 2017) using mixed methods that involved a survey of 350 engineers (due to late completion of 25, only 325 were included in the analysis) to derive quantitative data (Mansell, et al., 2020b) along with interviews with 40 CEOs and corporate Heads of Sustainability to capture qualitative data (Mansell, et al., 2020c). The second stage involved the development of a prototype that was examined[12] through further exploratory investigations at two levels: (1) Test 1: is there a Golden Thread from global SDGs, through the organisational-level, down to project level SDG impact measurement (Mansell, et al., 2019a); (2) Test 2: does the prototype model, the *Impact Value Chain*, have coherence in the analysis of a brief case study investigation that, through application of the main findings from the empirical stage, evaluated the scope to measure SDG performance for infrastructure projects at a Water Utility Company (Anglian Water) (Mansell, et al., 2020d).

The Logic Map shown below in Figure 76 illustrates the development of the Propositions and the C-M-O Variables Framework. The red boxes and red connecting lines illustrate how this measurement framework was built and how it flows. It highlights the connecting loop, that starts from the SLR, connects through a series of evidence gathering and development stages, and returns in the Concluding Chapter to answer the Research Question, Objectives and Propositions originally established in Chapters 1 and 2.

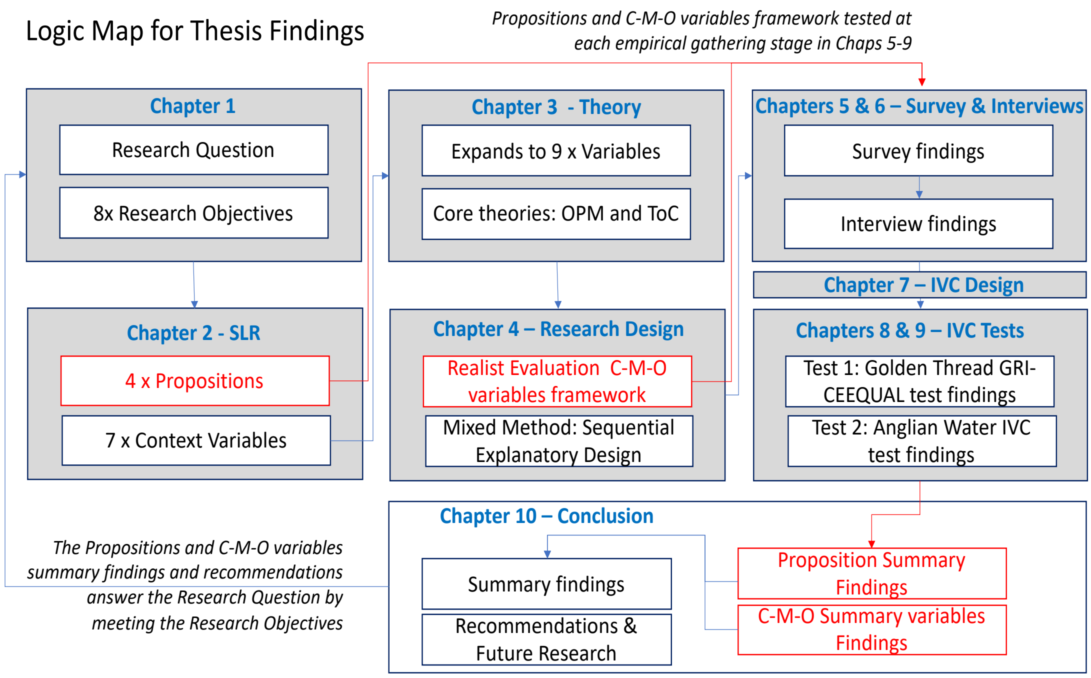


Figure 76. Logic Map for Thesis Findings.

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[12] **Note**. The 'tests' are more aligned to a demonstration. Eg. The research of MISI at Anglian Water was only envisaged as an initial demonstration of the utility of the IVC approach, rather than any kind of full-blown test. It provided insights that informed the full test that was subsequently completed with the Environment Agency and Thames Tideway megaproject from December 2019 to April 2020. Therefore, 'tests' should be viewed as providing 'guidance' not 'confirmation' of the IVC's utility.

Each chapter, with its unique research focus, captured the main findings from its research at the end of each stage, and linked this sequentially to the next steps of the investigation. In this way, the evidence is cumulatively built. This final chapter provides summary findings from each chapter in a holistic review against the overall research question. This is structured against four areas, listed below:

- **Results Area #1: Research Objectives** results are captured in Section 10.2.1 and in Table 34;
- **Results Area #2: C-M-O Variables Framework** results are shown in Section 10.2.2;
- **Results Area #3: Propositions'** cumulative evidence supporting the assessment of its results are described in Section 10.2.3; and
- **Results Area #4: Recommendations** are discussed in Section 10.2.4.

10.2.1 Summary Results against the Research Objectives

Based on the **research question**: 'How can global SDG goals be used to define and measure infrastructure projects' SDG impact at organisational and local project levels?', the table below summarises where the research investigation sought to achieve the **research objectives** and whether, in the view of the researcher, they were met. The more detailed evidence to support the analysis of research findings, is captured in Sections 10.2.2 to 10.2.4. This sub-section, shown in Table 34 below, seeks to reflect on the original Research Objectives, where they were evaluated and whether they were achieved.

Table 34: Research Objectives Summary.

Research Objectives	Summary of where investigation completed	Was the Research Objective met?
RO1: To understand the <u>existing knowledge</u> (in theory and practice) on how organisations and projects measure infrastructure projects' SDG Impact.	• Literature Review (Ch 2); Theory (Ch 3); • Survey (Ch 5); • Interviews (Ch 6)	High confidence that the objective was met by ensuring wide networking with academic and practitioners to test validity of research findings eg through 12 peer-reviewed publications in international journals & conferences
RO2: To understand the <u>context</u> (the 'variables') of the current use of mechanisms to measure	• Literature Review (Ch 2); Theory (Ch 3); • Survey (Ch 5); • Interviews (Ch 6)	High confidence that the objective was met due to extensive publications of research findings

infrastructure projects' SDG Impact.		as well as coherence in model development and trials.
RO3: To assess the current mechanisms used for the Measurement of Infrastructure projects' SDG Impact (MISI) at portfolio and project levels.	• Theory (Ch 3); • Survey (Ch 5); • Interviews (Ch 6)	High confidence that the objective was met from the extensive feedback through surveys and interviews.
RO4: To understand the perception of individual engineers and organisations' relative perception of the outcomes of the current use of mechanisms to measure infrastructure projects' SDG Impact	• Survey (Ch 5); • Interviews (Ch 6)	As above
RO5: To use the theory-led study to inform the development of a prototype model to improve the measurement of infrastructure projects' SDG Impact	• Development of the Prototype (Ch 7); • Conclusions and Recommendations (Ch 10)	High confidence that the objective was met because the model have been tested and feedback from practitioners provided that it can demonstratively support organisations MISI efforts.
RO6: To test whether a 'golden thread' of SDG measurement could be identified from global to local levels.	• Case Study (Ch 8) Test 1: GRI & CEEQUAL	High confidence that the objective was met through the findings from the Chapter 8 demonstration.
RO7: To test whether the prototype could be validated with a case study organisation.	• Case Study (Ch 9) Test 2: Water utility company	High confidence that the objective was met through the findings from the Chapter 9 demonstration.
RO8: To build a framework for further development, for researchers and practitioners to utilise, driving improved investment decisions across planet, profit and people outcome criteria, aligned to SDG impacts.	• Theory (Ch 3); • Triangulation of Results and Development of a Prototype • Conclusions and Recommendations (Ch 10)	High confidence that the objective was met by having an evidence-based development of the theories of ToC and TBL to underpin the IVC. Evidence from the practitioners that are using the research outputs also confirms success as shown in Appendices 17-23.

10.2.2 Summary Results against the C-M-O Variables Framework

The MISI study sought to answer whether the existing UN SDG goals are adequate for defining success at project level in the infrastructure sector. The conceptual development was based on literature research across the Triple Bottom Line and the Theory of Change. This enabled the development of a theoretical model, the Impact Value Chain (IVC), that provided a mechanism that could be tested across three levels, including the business-portfolio, the mega-project and the project levels, which has recently been completed at the Environment Agency and Tideway Tunnel's mega-project. Although the results are not included in detail in this thesis, the organisations have agreed for their letters of impact support from this research project to be included in Appendices 17-23.

The resultant view against the C-M-O Variables Framework after the Test 1 and 2 (note caveat in Footnote 9 above), is shown below, based on critical analysis of the Tests' results. As discussed in Chapter 8, the 'Harvey Balls' are commonly used in comparison tables to illustrate the degree to which a particular item meets a particular criterion, and users of them, such as Groenland (2016), suggest that they discourage readers of a report from '*attributing quantitative meanings to qualitative data*'. In this case, the Harvey Balls indicate that there is reasonable strength of findings for seven of the nine contextual issues, two of the three mechanism issues and for both of the two outcome issues. In effect, C6, C7 and M3 would need further research to strengthen the findings.

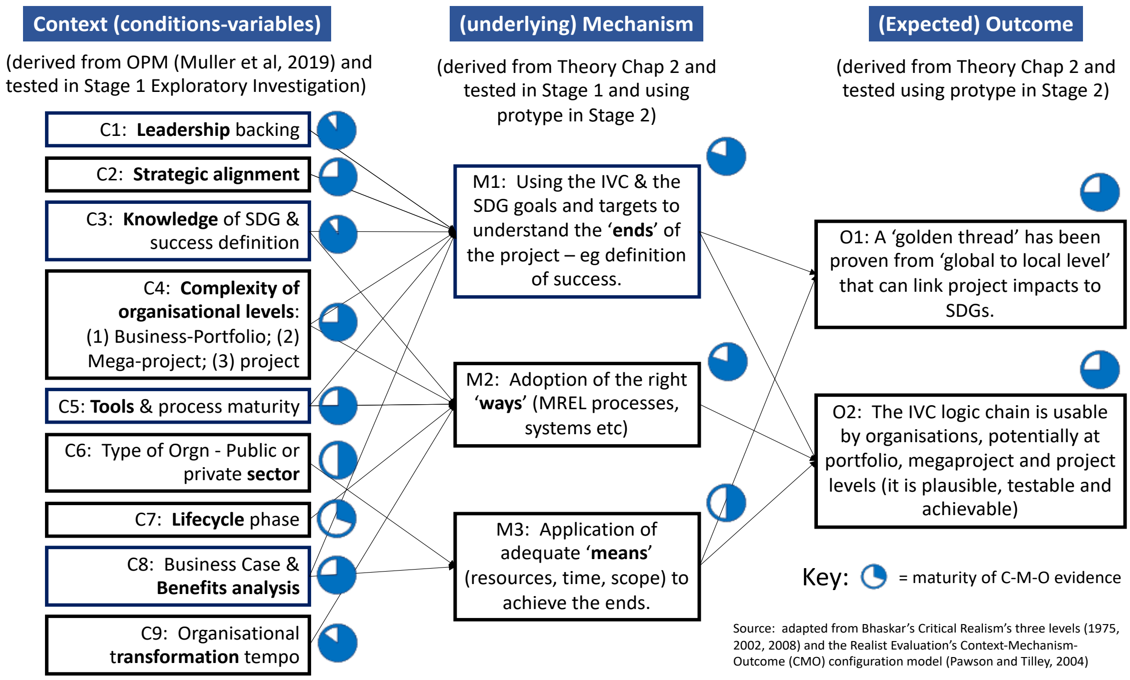

Figure 77. View 3 – Maturity of C-M-O evidence across variables post-Tests 1 & 2.

A summary of the results from the investigation into the C-M-O Variables Framework, shown below in Table 35, indicates that the MISI study has added new knowledge to address a gap in the current understanding. The confidence rating for the derived stability of the findings is shown in column 'b', that is based on the evidence listed in column ‘c’. This leads to the conclusion that the framework is robust and provides a solid basis for further MISI development, in that the C-M-O has allowed the logical experimentation of causal chains, both horizontally as well as vertically, across portfolio-megaproject-project boundaries. The analysis of the Variables Framework has also indicated that some of the variables will require further investigation. Suggestions for the nature of the future work is captured in column ‘d’.

Table 35: Summary Results of C-M-O Variables Framework.

C-M-O Variables (a)	Confi-dence (b)	Research Findings (with ref) (c)	Future Work (d)
		Context (conditions-variables) **derived from SLR ‘Issues & Variables’ & OPM (Muller et al, 2019)**	
Context 1: Leadership backing.	High	• Leadership was identified as a dominant contextual issue in the measurement of SDG impacts at organisational and project levels. • Because of the leaders role in transformation, which lies at the core of adopting the SDG lens to measure business and project success, the importance of strong direction with visible leaders was strongly referenced as critical success factors in the survey and the interviews. • The SDGs have similar complexity patterns to sustainability, with an equal need for adaptive systems that place an extraordinary demand on leaders. • Leaders need the skillsets that can balance the complexities of achieving the economic business success of profitability with the increasing demands on co-balancing with environmental and social objectives. • The visionary leaders will be the ones that harness the CSV mindset and then can empower and align their organisations with the people, profit and planet thematics of TBL, thinking and acting within ‘systems of systems’ models that seek innovative solutions to the SDG challenges.	The development of a new theoretical lens in Chap 7, the IVC, should be supported by tools and processes that enable the practical application of the proposed IVC model. Potential for a re-run of the original survey conducted in June 2018, to test emerging positions. The Environment Agency and Thames Tideway megaproject are currently undergoing their own trials, championed by their leaders.
Context 2: Strategic Alignment.	Moderate-High	• Recognition of the need for using benefits and impact performance measurement to ensure strategic plans are delivered effectively and efficiently, aligned to corporate and stakeholders goals. SDGs were agreed as a good way to achieve this with a common lexicon. • CEO’s mentioned that a MISI tool needs to ensure strategic alignment, which aligns with use of the ‘ends, ways, means’ model using the Theory of Change.	Needs ‘live’ testing with organisations at the portfolio, megaproject and project levels to ensure practical, plausible, achievable use of IVC.

		• The results showed that interview participants have placed a high priority in strategic alignment of project goals with SDGs and also have the resolve to employ SDG measurement at business and project levels (Finding #2) in order to achieve outcomes that benefit people, the planet and profit. • The survey results (Chap 5, Finding #M2) highlighted the need to enhance business skills of engineers to better define benefits and impacts that can more effectively align with organisational strategic goals.	
Context 3: Knowledge of SDG & success definition	High	• The survey showed that engineers agreed that too often, projects define success by traditional outputs using the so-called 'iron triangle' of time/cost/scope (and quality) dimensions to deliver on the SDG goals. Instead, the majority of survey respondents agreed that the engineering and project management communities need to place a greater emphasis on the achievement of long-term outcomes aligned to SDGs and adopt a correspondingly broader definition of success. The survey results also indicated the need to build capability and capacity amongst engineers. • The interviews reinforced the point above, by noting the importance of defining success through outcomes and not just through the traditional outputs of time, cost and scope (and quality). • The broadening of skillsets to include business skills of innovation and definition of broader TBL success will play a more dominant part of the education and learning syllabus in future. In this regard, it was suggested by a number of respondents that embedding business skills learning within core engineering educational programmes would help provide opportunities for meaningful improvements in the measurement of SDG performance on projects.	The development of research into what changes to current education curriculum could be progressed and ideally with standards bodies such at the APM and ICE.
Context C4: Complexity of organisational levels: (1) Business-Portfolio; (2) Mega-project; (3) project	High	• The OPM model (Muller et al., 2019) provides useful insights to the organisational context and project context. The IVC prototype therefore needs to be flexible for the needs from portfolio, megaproject and project levels. • Although the survey questions did not specifically address the separate levels of organisations and projects, a number of the interviewees mentioned the need for a	There is an opportunity to continue the research with the Environment Agency and Thames Tideway to ensure a portfolio, megaproject and project

		coherent cascade of goals from portfolio to project level and a knowledge innovation return loop that shares measurement of benefits realisation (aligned to SDG). • That existing sustainability measurement at organisational and project levels is well established, and therefore, SDG measurement should be aligned to existing successful approaches, not created as an 'add-on' (i.e., the organisational level will likely have different SDG imperatives and reporting requirements, such as using the GRI, from the project level, which might have limited capability and capacity to track too many targets and indicators.) • This becomes important in the development of a prototype since the measurement of SDGs at the enterprise level (the portfolio) will likely be different from that at programme and project levels. This requires further research.	perspectives are incorporated into the future development of the IVC.
C5: Tools & process maturity	Moderate-High	• The engineers surveyed (Chap 5, Finding #C3) highlighted the need for simple tools to measure project success using the SDGs, that should guide the design of the prototype. • It was frequently noted that there was significant room for improvement on availability of 'fit for purpose' engineering tools and methodologies to measure SDGs. These results highlight the need for a new simple tool (such as a set of KPIs linked to the SDG indicators). • There is an opportunity to allow the engineering community to align projects' SDG reporting with the growing trend of using global standards to report sustainability. • The literature review also noted that there is a growing body of evidence (Allen et al., 2019; Bali Swain and Yang-Wallentin, 2020; Jones and Comfort, 2020) that suggests that the complexity of the 17 Goals and the 169 targets needs to be simplified and a reduced selection prioritised for measurement.	There is a need to maintain the pace of MISI development, with a strong focus on practical implementation. This aligns with the UK government's ambition to achieve Net Zero by 2050, which is one area that be tracked with meaningful data. There is potential to align with COP26 in Glasgow in Nov 2021 if MISI gains further traction with the Cabinet Office and HMT (BBC, 2021).
C6: Type of Organisation - Public or private sector	Low	• There was little coverage of the difference between public and private sectors. A few of the CEOs did refer to the challenges of MISI, where the client was not demanding SDG measurement as part of the procurement process.	There is an opportunity to continue the research with the Environment Agency and Thames Tideway to compare the

			differences and similarities of employing a MISI approach in the private and public sectors.
C7: Lifecycle phase	Low	• The OPM model also notes the project lifecycle imperatives and thus the prototype needs to be adaptable to different stages of the project. For example, the early definition stage will not have full details of the activities, but the prototype should align to the Green Book Five Case Model (5CM) so that it can be used across the public sector at the investment appraisal stage. • Both the Environment Agency and Thames Tideway MISI trials have tested the IVC on megaprojects that are c50% through the delivery phase as well as some that have been completed. It is anticipated by the Environment Agency that they will be ready to use the IVC by April 2021 on the full portfolio of projects, including new initiatives.	There is a future proposition for new research that might seek to verify whether there is greater utility of MISI at the investment stage of a project. MISI to continue to support the HMT/CO team to update the Green Book 5CM by making it 'greener'.
C8: Business Case & Benefits analysis	High	• The survey showed that many engineers agreed that the choice of SDG goals and targets should be primarily selected on the basis of business profitability. This is counter to CSV and TBL. As a result, the longer-term value of making investment decisions based on broader TBL principles could be weakened. It is therefore proposed that the next research stage, to inform the development of the prototype, investigates how the TBL could be integrated with the measurement of SDGs. As noted above (C7), this should be done in partnership with the HMT and Cabinet Office's Green Book update team. • Whilst recognising the imperative of ensuring short-term commercial success when delivering project engagements for clients, all CEOs recognised the importance of defining outcomes and benefits from the start, which assumes an explicit need to plan for longer-term impacts. The IVC model should align with the existing benefits realisation processes.	The development of a new theoretical lens in Chap 7, the IVC, should be supported by tools and processes that enable the practical application of the proposed IVC model. Potential for a re-run of the original survey conducted in June 2018, to test emerging positions.
C9: Organisational transformation tempo	Moderate-High	• A number of the interviewees noted the importance of building a coalition of the 'willing' and that the alignment would be enhanced by using the IVC's ToC and TBL to demonstrate progress on the achievement	Further research into the challenges of building a new measurement approach into

		of outcomes. In this way, evidence of success confirms the causal linkages and indicates that the initiative is effective in achieving its outcomes and SDG impacts.	existing processes. The Environment Agency have agreed to lead.
<u>(underlying) Mechanism</u> **(derived from Theory Chap 2 and tested in Stage 1 and using prototype in Stage 2)**			
M1: Using the IVC & the SDG goals and targets to understand the 'ends' of the project – eg definition of success.	High	• There was almost unanimous conviction that the "ends" of achieving the desired "outcomes" was good for business (Chapter 6, Finding #4) and this should be communicated when seeking to get organisations to engage with the IVC prototype. • The survey noted (Chap 5, Finding #C2) that 'definition of success' and 'excessive focus on outputs instead of outcomes' (Chap 5, Finding #O2) were two of the five top challenges facing practical application of MISI. • The model should harness the core concepts of the Theory of Change and the Logic Model, with their focus on outcomes measurement, including the analysis of causal linkages, engagement of stakeholders and strategic design with the 'ends' being the starting point for a right to left causal mapping. • Measurement of SDG performance should accommodate the perspective of Creating Shared Value (CSV) (i.e., seeking solutions that are good for business in the short and longer term through balance of profit–planet–people objectives). • This was supported by participants being optimistic that their organisation would achieve the broader outcomes by making SDG measurement more usable, consistent and verifiable across the construction sector, with increasing balance to their investment decisions across environment, economic and societal factors (Chapter 6, Finding #1).	Needs 'live' testing with organisations at the portfolio, megaproject and project levels. Increased emphasis on Climate Change and Net Zero by global players. Eg. in January 2021, 110 states had legally binding commitments, including China and led by UK in 2017 – (BBC, 2021)
M2: Adoption of the right 'ways' (MREL processes, systems etc)	High	• The survey highlighted a clear preference for measuring just five SDG goals (there was a 50% reduction in the preferences for the next two SDG goals). This indicated a long tail of ten further goals that did not appear to resonate as much with participants. • The findings from the survey on the top five SDGs and the complexity noted in the literature review is consistent with the	This indicates an important area for further research to assess how this simplification can be achieved at organisational and project levels.

		advice given by the UN Global Compact in their proposed methodology (GRI, 2015).	
M3: Application of adequate 'means' (resources, time, scope) to achieve the ends.	Moderate-Low	• Measurement of SDG performance should be viewed from a systemic perspective and thereby move beyond the traditional 'iron triangle' view of projects in the short term (i.e., according to schedule, budget, scope and quality performance) and additionally, take account of longer-term project outcomes and impacts. • The megaproject leaders that were interviewed were consistent in their view that there was a need to develop a MISI approach that focuses on the identification of interrelationships between components (i.e. sub-systems) of a system. The immediate design and testing of the prototype should include the steps to better understand the sub-systems from the start, such as breaking down the carbon issues across stakeholders and especially across the supply chain. • The fourth concept aligns the TBL with SDGs and strengthens the composite IVC value chain. The IVC prototype should therefore provide a means '*to determine stakeholder's preferences and the trade-offs they choose to make given their scarce resources, or the value the marketplaces on an item*' (Porter, 1985).	The development of a new theoretical lens in Chap 7, the IVC, should be supported by tools and processes that enable the practical application of the proposed IVC model. Potential for a re-run of the original survey conducted in June 2018, to test emerging positions.
(Expected) Outcome **(derived from Theory Chap 2 and tested using prototype in Stage 2, Chaps 8 & 9)**			
O1: A 'golden thread' has been reinforced from 'global to local level' that can link project impacts to SDGs.	Moderate-High	• Evidenced primarily from the Test 1 in Chapter 7. The conclusion was that there is strong evidence of a golden thread from SDG to GRI, and through the organisational level, down to projects. • Initially, the study identified a lack of evidence given by interview participants on their ability to achieve the golden thread of SDG measurement from project to portfolio level (Chap 6, Finding #10) because, often, it was not available at any credible depth or backed up by verifiable evidence. • This was examined further in Test 1 (Chap 7) to test whether aspirations to achieve this linkage are realistic. • A further prototype design criterion that emerged from the interviews, to enable the mechanism for measuring SDG impacts to achieve the outcomes, was the ability to find a golden thread from enterprise	There is a need to test and track the actual measurement of SDG targets. The Environment Agency are currently undergoing trials to assess the validity of this approach.

		portfolio level to project level (Chap 6, Finding #10).	
O2: The IVC logic chain is usable by organisations, potentially at portfolio, megaproject and project levels (it is plausible, testable and achievable)	High	• Evidenced primarily from Test 2 in Chapter 8. The Anglian Water case study indicated the IVC's value and relevance to existing organisations that wanted to harness SDGs to be more aligned with global challenges and methods to respond to them. • Measurement of SDG performance should accommodate the perspective of the Triple Bottom Line (i.e., social, environmental and economic performance). This will drive a broader definition of project sustainability that includes the three pillars (i.e., social, environmental and economic performance). It provides simplicity and structure for the analysis in regard to selecting and measuring SDGs. • Measurement of SDG performance should accommodate the required different organisational levels, namely portfolio, programme and project levels.	As above

The evidence collected from the investigation of the variables has informed the response to the Propositions, that are answered below.

10.2.3 Summary Results against the Propositions Framework

The final assessment of the maturity of evidence against the Propositions is shown in Table 36, below. This indicates that, as expected in a qualitative-based investigation, the empirical research has not given statistical certainty. However, it has, through the tracking of evidence maturity through the investigation stages, provided sufficient evidence to give confidence to the findings discussed at the end of each Chapter and in summary, below in Table 36. This summation is in-line with most qualitative led mixed research methods that can only give a view of the world, since as the Critical Realist philosophers (eg Bhaskar, 1999) might suggest, there is only a limited view of the real and actual worlds that empirical investigations uncover. Thus, the MISI study has supported the evaluation of the transitive domain through observation of events and people's interpretation of them. This leads to the summation of propositions' maturity of evidence shown below:

Table 36: Summary table of the stability of Propositions

Confidence in Evidence for Propositions	P1: Engineer's view of current MISI	P2: Organisational view of MISI	P3: 'Golden Thread' global - to - local	P4: Prototype Development
Theoretical Analysis	Not yet	Not yet	Very Low	Very Low
Survey Analysis	Moderate	Very Low	Very Low	Very Low
Interviews Analysis	High	Moderate	Very Low	Very Low
Test 1: Golden Thread	High	Moderate	Moderate	Moderate
Test 2: Case Study	High	Moderate-High	High	High

The grading assessment of the quality of propositions' evidence used the qualitative formula designed by the Clinical Grading Working Group's British Medical Journal's study (GRADE, 2004), based on a combination of quality and consistency. Using their definitions, (shown in full below Table 8), the evidence from the study has provided high confidence for Propositions 1, 3 and 4. This means that further research is very unlikely to change the confidence in the estimate of effect. Proposition 2 was slightly less strongly evidenced, and it is suggested that further research is likely to have an important impact on the confidence in the estimate of effect and may change the estimate. In addition to the maturation of evidence to respond to the propositions, shown above in Table 36, the summary of the thesis results is shown below:

10.2.3.1 Proposition 1: Individual engineers are 'supportive but frustrated' in methods to measure global SDG goals at project level.

- The survey provided empirical evidence that engineers (over 90% of the 325 surveyed) were very strongly supportive of measuring SDGs on projects. However, they noted a gap between what is wanted-needed and what is available, i.e. there is insufficient leadership; tools; processes; knowledge; and pace of change to support SDG adoption.
- There were extensive reasons offered to explain the gap, and these were captured in the C-M-O Variables Framework discussed in Table 35 above.
- It was frequently noted that there was significant room for improvement on availability of 'fit for purpose' engineering tools and methodologies to measure SDGs. The engineers surveyed (Chap 5, Finding #C3) highlighted the need for

simple tools to measure project success using the SDGs, that played a major part in the design of the prototype. This was realised by the development of a new theoretical lens in Chap 7, the IVC and the SDGiPro, that should be supported by tools and processes that enable the practical application of the proposed IVC model.

- The literature review also noted that there is a growing body of evidence (Allen et al., 2019; Bali Swain and Yang-Wallentin, 2020; Jones and Comfort, 2020) that suggests that the complexity of the 17 Goals and the 169 targets needs to be simplified and a reduced selection prioritised for measurement.
- **The first proposition is therefore supported by the research evidence.**

10.2.3.2 Proposition 2: Organisations' leaders champion SDG measurement without having evidence-based methods to verify claimed impact at portfolio and project levels.

- The interviews provided evidence of a 'gap' between organisations' MISI 'ambitions' and 'reality' by accepting that there is a mismatch between what companies 'say' they are doing and what they are 'actually' doing (this is sometimes characterised as 'greenwash'). There was evidence of a growing commitment to adopt the SDGs in the Anglian Water case study and the interviews supported this view by demonstrating that engineers are embracing the shift to SDG adoption, but are finding considerable contextual challenges to achieve MISI efficiently and effectively.
- The interviews confirmed that there is a wide variance in MISI knowledge and perceived value.
- There was almost unanimous conviction that the "ends" of achieving the desired "outcomes" was good for business (Chapter 6, Finding #4). Whilst the leaders recognised the challenges noted above, they wanted to move beyond 'greenwash'. They recognised that the new, and rapidly evolving, legal norms driven by the 'Net Zero in 2050' laws, that there was reputational and economic value in being seen to lead in their MISI commitments. This should be messaged when seeking to encourage organisations to engage with the IVC prototype.

- The survey noted (Chap 5, Finding #C2) that 'definition of success' and 'excessive focus on outputs instead of outcomes' (Chap 5, Finding #O2) were two of the five top challenges facing practical application of MISI.
- As a result of the findings from CEO's interviews, the prototype was developed further with greater focus on outcomes measurement, including the analysis of causal linkages, engagement of stakeholders and strategic design with the 'ends' being the starting point for a right to left causal mapping.
- It was noted that measurement of SDG performance should accommodate the perspective of Creating Shared Value (CSV) (i.e., seeking solutions that are good for business in the short and longer term through balance of profit–planet–people objectives). This was supported by participants being optimistic that their organisation would achieve the broader outcomes by making SDG measurement more usable, consistent and verifiable across the construction sector, with increasing balance to their investment decisions across environment, economic and societal factors (Chapter 6, Finding #1).
- **The second proposition is therefore supported by the research evidence.**

10.2.3.3 Proposition 3: Current sustainability measurement at organisational and project levels can be used to demonstrate a 'golden thread' from 'global' SDG to 'local' portfolio and project levels.

- Initially, the study identified a lack of evidence given by interview participants on their ability to achieve the golden thread of SDG measurement from project to portfolio level (Chap 6, Finding #10) because, often, it was not available at any credible depth or backed up by verifiable evidence.
- A further prototype design criterion that emerged from the interviews, to enable the mechanism for measuring SDG impacts to achieve the outcomes, was the ability to find a golden thread from enterprise portfolio level to project level (Chap 6, Finding #10).
- The evidence was subsequently derived from Test 1, as described in Chapter 7. The conclusion was that there is strong evidence of a golden thread from SDG global goals (by testing the GRI framework linkages to CEEQUAL and to SDGs) and through the organisational level, down to projects.

- There is a need to test and track the actual measurement of SDG targets. The Environment Agency are currently undergoing trials to assess the validity of this approach
- **The third proposition is therefore supported by the research evidence.**

10.2.3.4 Proposition 4: A MISI prototype can provide a plausible, testable and achievable logic chain for defining project and portfolio SDG impacts.

- This was evidenced primarily from Test 2 in Chapter 8. The Anglian Water case study demonstrated the IVC's value and relevance to existing organisations that wanted to harness SDGs to be more aligned with global challenges and methods to respond to them.
- The findings from the case study suggested that measurement of SDG performance can accommodate the perspective of the Triple Bottom Line (i.e., social, environmental and economic performance). This supports a broader definition of project sustainability that includes the three pillars (i.e., social, environmental and economic performance). It is also important to provide simplicity and structure for the analysis in regard to selecting and measuring SDGs.
- The case study indicated that measurement of SDG performance can accommodate the required different organisational levels, namely portfolio, programme and project levels.
- The evidence from the case study indicates there are high MISI performers, such as Anglian Water, at an early-adopter stage, that have potential to drive change across the sector.
- **The fourth proposition is therefore supported by the research evidence.**

The overall results indicate that SDG measurement practices are embraced in principle but are problematic in practice and that rarely does action match rhetoric. While the research was completed in the UK, the findings have broader applicability to other countries since most construction firms have extensive global business footprints.

Researchers can use the findings to extend the current understanding of measuring outcomes and impact at project-portfolio levels, and, for practitioners, the study provides insights into the contextual preconditions necessary to achieve the intended outcomes of adopting a mechanism for the measurement of SDGs. The national relevance of this research is corroborated by the project partners, whose letters confirming the derived Impact to their organisations of this work, are included at Appendices 17-23: Institution of Civil Engineers; the Buildings Research Establishment; the Cabinet Office's Infrastructure and Projects Authority; the Environment Agency; and, the UN Global Compact. These letters of support confirm that the research study has provided meaningful insights into how infrastructure investment can be focused to increase impact across SDGs with broader benefits in the longer-term achieved. It also demonstrates how the benefit of the MISI approach is aligned to Creating Shared Value that drives more successful and sustainable businesses with increased contributions across the TBL impacts of profit, people and planet.

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.

10.3 LIMITATIONS

The research is limited in time and space. As regards time, the study has not been longitudinal, as illustrated in Saunders' research Onion Ring in Figure 31 (Saunders, et al., 2009), because it has only investigated an event at a single point in time. Future research could include an assessment of whether the findings from the survey and interviews of this MISI study have evolved in light of increasing international awareness, such as at the COP26 global conference hosted in Glasgow in November 2021 (BBC, 2021). In terms of 'space' the study has had limited resources in terms of research bandwidth, and whilst the collaborative partnership with ICE, UCL, BRE, UN Global Compact, IPA, the Environment Agency and Tames Tideway megaproject have broadened and deepened the research, it has necessarily been constrained by the doctoral researcher's finite capacity.

There are inevitably limitations of the research study. Although a significant level of empirical analysis has been undertaken through the survey of 325 practitioners and interviews with 40 senior leaders along with the initial case study investigations, there is nevertheless scope for more detailed case study research to be carried out. In this regard, further case studies would build more detailed qualitative and quantitative data that the findings of the research study can be evaluated against. In this way, the proposed research will likely provide more meaningful insights into how infrastructure investment can be better focused and lessons that increase impact across SDGs will be applied more effectively. This is important because infrastructure projects have always been an essential underpinning aspect for society, but today's global business context gives new weight to infrastructure's importance, and this approach of measuring SDG impact at the project level provides a golden thread to link the projects' delivery outcomes with national and global SDG targets. Conversely, if projects do not widen the definition of success to incorporate SDG impacts, they will fail to accommodate the unique enabling role of engineering and infrastructure, inadvertently weakening the resilience and wellbeing of both business and society.

10.4 RECOMMENDATIONS

There are theoretical implications for the development of an adapted Theory of Change framework for future research into this embryonic study area. Most importantly, given the immediacy and Grand Challenge of achieving the SDG 2030 goals, practical application is significant since the Impact Value Chain has flexibility to be used at both project and portfolio levels (as described by the Environment Agency in their Impact Statement shown at Appendix 18), thereby linking tactical delivery on projects to organisational SDG impacts at the portfolio level and potentially leads to improved investment decisions with increased likelihood of success in achieving the SDG 2030 targets, involving broader benefits in regard to people, profit and planet considerations. The summary recommendations can be briefly stated across four themes as, shown below in Figure 78. Three of the recommendations are shown aligned to the project/portfolio lifecycle and business case stages, the fourth recommendation is to further the research into MISI and its IVC and SDGiPro methodology.

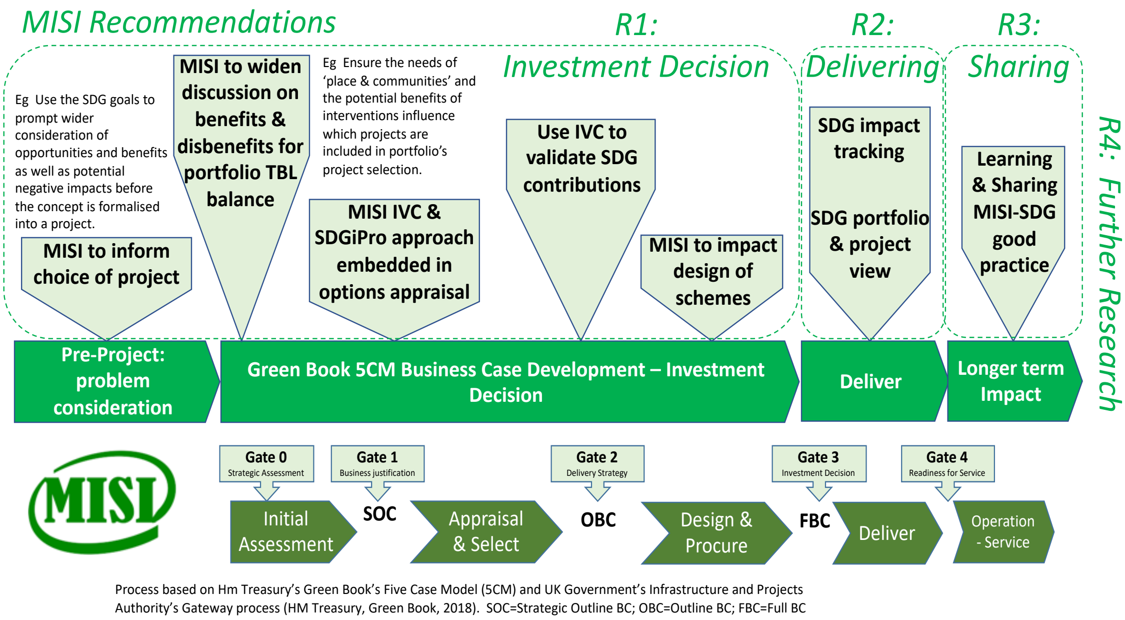

Figure 78. Lifecycle view of MISI Recommendations.

10.4.1 Recommendation 1 - The MISI (IVC and SDGiPro) approach should be used to support the Investment Decision stage of infrastructure projects and their strategic portfolios.

MISI should be used to:

- Inform the design and choice of the project by better understanding the broader, longer-term outcomes and impacts.
- Widen discussion on benefits and disbenefits for portfolios, thereby seeking stakeholder alignment with project's aims.
- Embed IVC framework in the options appraisal stage by using the adapted ToC theory to enable an SDG causal chain and a TBL trade-off.

The IVC and SDGiPro should be used during the problem consideration and design phase (through the appropriate use of the adapted causal logic chains of the ToC and TBL theories) to increase the likelihood that stakeholders will have clearly specified the initiative's intended outcomes, the activities that need to be implemented in order to achieve those outcomes, and the contextual factors that are likely to influence them. In this way, the early use of the IVC at the concept stage of project design helps show how activities will lead to interim and longer-term outcomes and SDG impacts. It also identifies the contextual conditions (as developed in the MISI 'Variables Framework') that may affect them. This helps strengthen the business case for attributing subsequent change in these outcomes (from initial levels) to the delivery of project activities and outputs.

This recommendation has been actively taken forward with the UK Government's Infrastructure and Projects Authority who have leveraged the MISI work by employing the researcher to propose edits to the new Green Book's (2018) updates to include SDG measurement. Therefore, this recommendation can be viewed in the context of extending the field of ToC/TBL into project sustainability and indeed, the thematical framework of the Green Book's Five Case Model (5CM)[13]. It is anticipated that by influencing the new edits to the 5CM, the MISI research will achieve significant indirect influence on investment decisions.

10.4.2 Recommendation 2 - The IVC should be used to facilitate the measurement and data collection (monitoring, reporting and evaluation) process.

MISI should be used to:

- Shape the project and portfolio MRE (monitoring, reporting and evaluation) process of SDG-benefits/disbenefits.
- Validate SDG contributions and separate direct attribution from indirect contribution.

The adaption of the ToC and TBL theories provides the building blocks of any effective evaluation, but they are especially useful for mid-course feedback to managers and for developing a knowledge base about how and why SDG

[13] The Green Book's Five Case Model is the core document and approach for the justification of taxpayers' money, through a defined business case protocol.

measurement can be applied. For example, the IVC (and SDGiPro) asked that participants be as clear as possible about not only the ultimate outcomes and SDG impacts they hope to achieve but also the avenues through which they expect to achieve them (Weiss, 1995). An evaluation based on a ToC and TBL, therefore, identifies what to measure, ultimate and interim outcomes, and the implementation of activities intended to achieve these outcomes. It also helps to guide choices about when and how to measure those elements. The unique insight of this research is that MISI, through alignment of ToC and TBL in a single framework, provides a new way to find a causal pathway to SDG impacts, which allows a clearer measurement framework with a vocabulary that enables stakeholders to align around short and longer term TBL-SDG outcomes and impacts.

10.4.3 Recommendation 3 - The MISI approach should be used to support knowledge building through the learning and sharing from MISI good practice.

MISI should be used to:

- Complete the learning stage of the MREL for the benefit of further research and also for practitioners.
- Build confidence in leaders' selection of 'stretch' SDG targets that they might not achieve, such as ambitious Net Zero targets.
- ICE should bring together industry leaders (at all levels, not just CEOs) to champion the adoption of realistic, practical and verifiable MISI.

MISI could contribute to the learning stage of the MREL process by providing the link from local to regional, national and global goals. In doing so, the lessons have potential to have wider utility than the local project and could be leveraged for greater benefits. For example, lessons from MISI on a water project in East Anglia (UK) could have relevant lessons for an international development project in East Africa.

MISI lessons sharing should leverage this research by using the ICE as a trusted organisation to build a coalition of willing leaders (CEOs and key individuals across the age and gender spectrum) to share their MISI experiences so that others may benefit, even if they underperform in achieving their aspired SDG targets.

MISI could also be used by the ICE to build engineers' better understanding of the MISI business knowledge embedded in the IVC (ToC, TBL and CSV) and the definition of SDG outcome success. This could be considered as a potential broadening of a civil engineer's (and other related professions) professional qualifications.

10.4.4 Recommendation 4 - The MISI research should be used to guide future research with potential implementation of an enhanced knowledge and learning protocol for infrastructure stakeholders.

MISI should be used to:

- Establish a basis for further research that builds on early empirical evidence from working with the Environment Agency and Tideway Ltd.
- Build a MISI indicator framework, based on MISI learnings, that enables project leaders to select which of the targets and indicators are relevant for their size of project.
- Seek funding for the establishment of a MISI Centre of Excellence that can sustain the learning.
- Consider cross-disciplinary approaches, such as with Artificial Intelligence, to find ways that can leverage large quantities of data to better inform the learning cycle.

The study provides a foundation to guide future research on project and portfolio capabilities based on the MISI Variables Framework established through this study. This should include the development of an indicators framework, derived from the existing UN SDG targets and indicators as well as those used at the portfolio level (by the GRI) and project level (such as CEEQUAL), thereby building on the SDG golden thread established in Chapter 8.

The study has implications for the operations field, broader project studies, leadership/governance studies, international development studies, supply chain management and many other areas. Each of these have overlaps and perhaps even more opportunity lies with multi-disciplinary studies, such as seeking to work with the education sector to share ideas on how to develop knowledge and feed it into professional learning courses, such as suggested by the ICE, who have proposed leveraging the MISI research to enhance their professional learning and development courses (as discussed in Recommendation 3).

It is also proposed that further research uses the IVC model and the SDGiPro methodology to develop an improved understanding of the organisational context within which the definition and measurement of infrastructure project success is made. It could be used to examine the leadership and governance theories and relationships that underpin the overall analysis of project success definition and measurement. For example, recent studies (Müller, 2017) have provided clarity on how project governance, that shapes the reporting, directing and management of projects, is best understood by scrutinizing the overlapping influences of corporate governance at the organisational level and the separate, but related, governance at project level that has its own customs, rules and approaches for reporting project success.

10.5 MISI IMPACT AND IMPLICATIONS FOR FUTURE USE

The research produced twelve peer-reviewed papers including being published in seven internationally recognised academic journals, such as: *Sustainability* (2 articles), *Administrative Sciences*, and the *Proceedings of the Institution of Civil Engineers–Engineering Sustainability*. The MISI research outputs have been taken forward by the government and industry partners, specifically the Environment Agency and Thames Tideway Project, working together to establish this new approach for measuring sustainability on infrastructure projects.

10.5.1 Future Work – MISI with Environment Agency and Thames Tideway

A useful derivative of the MISI research has been the collaborative partnership to test the prototype model and its approach across the Environment Agency's full portfolio of projects and also, the Thames Tideway Tunnel megaproject. Although this detailed case study was an extension to the MISI research captured in this thesis, the ongoing and future Environment Agency and Tideway work has provided a platform for further investigations to highlight the utility and applicability of the IVC.

However, the 4-month in-depth case study of using the IVC in the 'real world', that was entirely led and designed by the doctoral researcher, has provided further insights into the applicability, usefulness, coherence and utility by these leading government and private sector organisations. The support letters proving the veracity of this MISI doctoral research impact is evidenced by senior leaders' letters in Appendices 17-23. The practical application is significant since, with improved linkage of tactical delivery to strategic SDG impacts, improved investment decisions will be made, and systemic level lessons can be applied to increase the likelihood of success in achieving the SDG 2030 targets.

10.5.2 Future Work – Learning from MISI research approach

The next stage of the research is to develop the infrastructure SDG measurement methodology proposed in Figure 61 into a fully defined methodology that is adaptable to the scale of the project and also its position in the project-programme-portfolio hierarchy. Thus, the model could be tested in active projects. The existing case studies could be broadened to include both developing and developed countries, and this might focus on a single asset type across the national economic infrastructure categories of energy, waste, water, transport and ICT.

The future research could close the current gaps of the existing propositions (as discussed above in sections 10.2.2.1-10.2.2.4) by application of a greater emphasis on 'engaged' research design, as introduced in Chapter 5 (Table 10) and now updated in Table 37 below.

Table 37: Critical Realist Research Designs (amended from Vincent and O'Mahoney, 2018; Ackroyd and Karlsson 2014)

	Intensive ←→ Extensive (a)			
	What is the mechanism?	*How do context & mechanism typically behave x OPM levels?*	*How do context & mechanism historically interact?*	*What are the context variables that impact outcomes?*
Detached (b)	Case-study (Future MISI)	Comparative case-study (Future MISI study)	Institutional / historical analysis	Surveys
Engaged (c)	Action research (Future MISI)	Intensive realist literature evaluations	Barefoot research (Future MISI)	Extensive realist evaluation

Based on this critical realist framework, the proposed future research design methods could be developed as follows:

- **Case-study**. The most frequent form of CR research that enables MISI to test the exploration of using the IVC prototype to assess whether it is practical, plausible and achievable. The next case study would seek to align the application of the IVC with existing business case design (Green Book, 2018) and also the existing protocols of benefits realisation.

- **Organisational behavioural impacts**. The discussion in Chapter 5 introduced the work of Peter Morris (2017) and Frank Geels (2007). Both apply systems thinking to seek understanding of complex relationships between operating models of strategy, processes, systems and people. Further study could harness these insights to consider organisational change models such as Kotter (2012) to explore the interaction of stakeholders on the IVC model. The research could align with the Institution of Civil Engineers' current and future topics of '*Transformative Collaborations*' (as part of Project 13) and '*Shaping Net Zero*' (the 2021 President's primary knowledge campaign) that have strong parallels with the MISI area of study.

- **Action research**. The summary results suggest this as a proposed new research phase of the MISI study, with the Environment Agency and Thames Tideway megaproject. This method of research was discounted in Chapter 4, Section 4.3.2, due to a lack of time, resources and buy-in from potential organisations to develop the approach with. However, in the final 12 months of the doctoral research a strong collaboration with the Environment Agency has opened the way for an Action Research based approach in future. This would allow the training of the employees to jointly work with the lead researcher to develop the follow-on 'trials stage'. This is currently the case at the Environment Agency, where the Chair of the organisation has sanctioned the Portfolio Design team to take forward the learnings from the earlier MISI research work. The CEO of the Cabinet Office's Infrastructure and Projects Authority has explicitly backed this approach to widen the use of SDGs across the full government portfolio of projects.

- **Comparative case-study**. The proponents of this approach such as Kirkpatrick et al. (2005) and Delbridge (1998) suggest this as a suitable way to explore how similar mechanisms operate in different contexts. So, for example, this might be chosen as the proposed approach for future research, beyond this thesis write-up, as a way to more comprehensively test the IVC across the OPM levels of portfolio and project levels with the Environment Agency and the megaproject level with Thames Tideway.

- **Barefoot research**. Lindqvist (1979) describes how organisations can develop their own interpretations by use of training and encouraging employees of the case study organisation to do their own research. This is the proposed approach to be taken with the collaborative MISI partnership between the Environment Agency and Thames Tideway megaproject, whereby they can be trained to develop their own solutions based on the MISI research findings from this thesis.

10.6 PERSONAL REFLECTIONS

This has been a long journey. It has been a privilege to conduct the research with such a broad range of senior collaborative partners. It has allowed the opportunity to harness 'concrete experience', as proposed by Kolb's (1981, 1984) Experiential Learning Cycle theory, to help inform my approach across the other three stages: Reflective Observation of the New Experience; Abstract Conceptualisation; and, Active Experimentation. Through this process, which is actually a continual series of smaller loops, each producing insights, set-backs, connections and experiences, the learning iterations have successfully increased the knowledge in the MISI area. The challenge is to now identify how I can contribute to the wider issues of influencing government policy to increase TBL and SDG impact at project and portfolio levels. This has started by the invitation in October and November 2020 from the Cabinet Office to use the PhD MISI knowledge to suggest 'green' sustainable development updates to the family of government investment decision guidance books, known as the 'Green Books'. Ultimately, this will ensure the MISI research achieves the greatest impact from its insights. Future infrastructure investment decisions in UK and abroad could proactively use the IVC to help broaden their definition of success to include the TBL of profit, planet and people to drive a more sustainable future for us all, whilst supporting the achievement of the UN's 2030 SDG ambitions.

As Antonio Guterres, the UN Secretary General, says in October 2020:

"As Member States recognized at the SDG Summit held last September, global efforts to date have been insufficient to deliver the change we need, jeopardizing the Agenda's promise to current and future generations. Now, due to COVID-19, an unprecedented health, economic and social crisis is threatening lives and livelihoods, making the achievement of Goals even more challenging' (UN, 2020). He suggests our immediate and concerted global efforts in 2021, and specifically COP26 hosted by UK in November 2021 in Glasgow, is of paramount importance. He concludes:

'We are at a make or break moment" (BBC, 2021).

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Appendices

Appendix 1 - Table of SLR data across the MISI Research Thematics

The main data points from the SLR analysis have been collated into the table below that summarises the key thematics across the seven codified areas. This provides a high-level overview of the focus areas of the selected dataset.

Table 38: Consolidated table of data across the seven MISI Thematics

Combined Search Keywords	Authors	Article Title	Type of Contribution	Primary Research Design	Primary Geographical Focus	Infrastructure Sector Focus	Industry / Narrowed Sector	Level	SDGs Mentioned
SDG & Project	Hall R.P., Ranganathan S., Raj Kumar G.C.	A general micro-level modelling approach to analyzing interconnected SDGs: Achieving SDG 6 and more through multiple-use water services (MUS)	Framework proposition	Multiple case study	Mozambique	Water	Rural water services	Project; Organisational	SDG 6
SDG & Project	Klaufus C., van Lindert P., van Noorloos F., Steel G.	All-inclusiveness versus exclusion: Urban project development in Latin America and Africa	Framework proposition	Multiple case study	Latin America & Africa	Urban development	N/A	Local; Sectoral	SDG 11
SDG & Project	Farinosi F., Giupponi C., Reynaud A., Ceccherini G., Carmona-Moreno C., De Roo A., Gonzalez-Sanchez D., Bidoglio G.	An innovative approach to the assessment of hydro-political risk: A spatially explicit, data driven indicator of hydro-political issues	Framework proposition	Empirical analysis	Global	Water	Trans-boundary resources	Global	SDG 6.5.2

Combined Search Keywords	Authors	Article Title	Type of Contribution	Primary Research Design	Primary Geographical Focus	Infrastructure Sector Focus	Industry / Narrowed Sector	Level	SDGs Mentioned
SDG & Project	Dean K., Trillo C., Bichard E.	Assessing the value of housing schemes through sustainable return on investment: A path towards sustainability-led evaluations?	Framework testing	Multiple case study	United Kingdom	Housing	Social housing	Project	SDG 11
SDG & Project	Goel A., Ganesh L.S., Kaur A.	Deductive content analysis of research on sustainable construction in India: current progress and future directions	Framework proposition	Systematic literature review	India with developing economy reach	Not specified	Construction	Industry	General
SDG & Project	Heravi G., Fathi M., Faeghi S.	Evaluation of sustainability indicators of industrial buildings focused on petrochemical projects	Theoretical	Empirical analysis	Iran	Buildings	Industrial (Petro-chemical)	Industry	General
SDG & Project	Ding X., Zhou C., Mauerhofer V., Zhong W., Li G.	From environmental soundness to sustainable development: Improving applicability of payment for ecosystem services scheme for diverting regional sustainability transition in developing countries	Framework proposition	Single case study	China	Water	Water transfer	Regional; National	General
SDG & Project	Lucas P.L., Hilderink H.B.M., Janssen P.H.M., KC S., van Vuuren D.P., Niessen L.	Future impacts of environmental factors on achieving the SDG target on child mortality—A synergistic assessment	Framework testing	Empirical analysis	Global	Health, Water, Energy Nexus	N/A	Global	General
SDG & Project	Ishikawa Y., Murata M., Kawaguchi T.	Globally applicable water quality simulation model for river basin chemical risk assessment	Framework testing	Single case study	Japan	Water & Sanitation	River basins; Water quality	Organisational	General

Combined Search Keywords	Authors	Article Title	Type of Contribution	Primary Research Design	Primary Geographical Focus	Infrastructure Sector Focus	Industry / Narrowed Sector	Level	SDGs Mentioned
SDG & Project	Wang W., Chen J., Liu Q., Guo Z.	Green project planning with realistic multi-objective consideration in developing sustainable port	Framework proposition	Single case study	China	Port	N/A	Sectoral	General, leaning towards environmental
SDG & Project	Zhang L., Chu Z., He Q., Zhai P.	Investigating the constraints to building information modelling (BIM) applications for sustainable building projects: A case of China	Exploratory	Empirical analysis	China	Buildings	Sustainable buildings	Local; Sectoral	General
SDG & Project	Calderón Márquez A.J., Cassettari Filho P.C., Rutkowski E.W., de Lima Isaac R.	Landfill mining as a strategic tool towards global sustainable development	Exploratory	Multiple case study	North America, Europe, Asia and the Middle East	Waste management	Solid Waste	Regional; Global	General
SDG & Project & Infrastructure	Dushenko M., Bjorbaek C.T., Steger-Jensen K.	Application of a sustainability model for assessing the relocation of a container terminal: A case study of kristians and port	Framework testing	Single case study	Scandinavia	Port	N/A	Industry	General
SDG & Project & Infrastructure	Terrapon-Pfaff J., Ortiz W., Dienst C., Gröne M.-C.	Energising the WEF nexus to enhance sustainable development at local level	Framework testing	Empirical analysis	Global south	Water, Energy, Food Nexus	N/A	Project	General
SDG & Project & Infrastructure	Menhas R., Mahmood S., Tanchangya P., Safdar M.N., Hussain S.	Sustainable development under Belt and Road Initiative: A case study of China-Pakistan Economic Corridor's socio-economic impact on Pakistan	Theoretical	Single case study	Pakistan	Multi-sector	N/A	Regional	General

Combined Search Keywords	Authors	Article Title	Type of Contribution	Primary Research Design	Primary Geographical Focus	Infrastructure Sector Focus	Industry / Narrowed Sector	Level	SDGs Mentioned
SDG & Project & Infrastructure	Anwar B., Xiao Z., Akter S., Rehman R.-U.	Sustainable urbanization and development goals strategy through public-private partnerships in a South-Asian metropolis	Theoretical	Multiple case study	South Asia	Urban development	Mega-cities; PPPs	Regional	SDG 11
SDG & Infrastructure	Schwanitz V.J., Wierling A., Shah P.	Assessing the impact of renewable energy on regional sustainability-A comparative study of Sogn og Fjordane (Norway) and Okinawa (Japan)	Framework proposition	Multiple case study	Norway; Japan	Energy	Renewable energy	Regional	General
SDG & Infrastructure	Diaz-Sarachaga J.M., Jato-Espino D., Castro-Fresno D.	Evaluation of LEED for neighbourhood development and envision rating frameworks for their implementation in poorer countries	Framework testing	Multiple case study	Developing countries	Urban development	N/A	Project	General
SDG & Infrastructure	Sperling J., Romero-Lankao P., Beig G.	Exploring citizen Infrastructure and environmental priorities in Mumbai, India	Theoretical	Empirical analysis	India	Urban development	N/A	Local	General, leaning towards SDG 11
SDG & Infrastructure	Aust V., Morais A.I., Pinto I.	How does foreign direct investment contribute to Sustainable Development Goals? Evidence from African countries	Theoretical	Empirical analysis	Africa (44 countries)	Multi-sector	N/A	National; Regional	General, leaning towards SDG 13
SDG & Infrastructure	Wei X., Xu H., Zhang B., Li J.	Infrastructure operation efficiency and influential factors in developing countries: Evidence from China	Exploratory	Multiple case study	China	Roads	Expressways; Toll road operations	Industry	General
SDG & Infrastructure	Fuldauer L.I., Ives M.C., Adshead D.,	Participatory planning of the future of waste management in small island developing states to deliver on the	Framework proposition	Single case study	Curacao	Waste management	N/A	National	General

Combined Search Keywords	Authors	Article Title	Type of Contribution	Primary Research Design	Primary Geographical Focus	Infrastructure Sector Focus	Industry / Narrowed Sector	Level	SDGs Mentioned
	Thacker S., Hall J.W.	Sustainable Development Goals							
SDG & Infrastructure	Zheng B., Bedra K.B.	Recent sustainability performance in China: Strength-weakness analysis and ranking of provincial cities	Framework proposition	Empirical analysis	China	Urban development	N/A	Local	General
SDG & Infrastructure	Di Vaio A., Varriale L.	SDGs and airport sustainable performance: Evidence from Italy on organisational, accounting and reporting practices through financial and non-financial disclosure	Framework testing	Multiple case study	Italy	Airports	N/A	Organisational; Industry	SDG 11, 17
SDG & Infrastructure	Teferi Z.A., Newman P.	Slum regeneration and sustainability: Applying the Extended Metabolism Model and the SDGs	Framework testing	Single case study	Ethiopia	Urban development	Slums and settlements	Local	SDG 1
SDG & Infrastructure	da Silva L., Marques Prietto P.D., Pavan Korf E.	Sustainability indicators for urban solid waste management in large and medium-sized worldwide cities	Framework testing	Multiple case study	Brazil	Waste management	Solid waste	Local	General
SDG & Infrastructure	Monteiro N.B.R., da Silva E.A., Moita Neto J.M.	Sustainable development goals in mining	Exploratory	Multiple case study	Brazil	Mining	N/A	Industry	SDG 1, 2, 5, 8, 13
SDG & Infrastructure	Makino T., Noda K., Keokhamphui K., Hamada H., Oki K., Oki T.	The effects of five forms of capital on thought processes underlying water consumption behaviour in suburban vientiane	Framework testing	Empirical analysis	Vientiane, Lao	Water	Water supply	Local	General
SDG & Infrastructure	Cheng S., Li Z., Uddin	Toilet revolution in China	Exploratory	Literature review	China	Sanitation	N/A	National	General, leaning

Combined Search Keywords	Authors	Article Title	Type of Contribution	Primary Research Design	Primary Geographical Focus	Infrastructure Sector Focus	Industry / Narrowed Sector	Level	SDGs Mentioned
	S.M.N., Mang H.-P., Zhou X., Zhang J., Zheng L., Zhang L.								towards SDG 6
SDG & Infrastructure	Munyasya B.M., Chileshe N.	Towards Sustainable Infrastructure Development: Drivers, barriers, strategies, and coping mechanisms	Theoretical	Empirical analysis	Australia	Not specified	Construction	Industry; Sectoral	General
SDG & Infrastructure	Zhang Q., Liu S., Wang T., Dai X., Baninla Y., Nakatani J., Moriguchi Y.	Urbanization impacts on greenhouse gas (GHG) emissions of the water Infrastructure in China: Trade-offs among sustainable development goals (SDGs)	Framework testing	Empirical analysis	China	Water, Energy Nexus	N/A	Local; Regional	SDG 6, 11, 13
SDG & Infrastructure	Jama A.A., Mourad K.A.	Water services sustainability: Institutional arrangements and shared responsibilities	Theoretical	Empirical analysis	Somalia	Water	Water supply	Sectoral; National	SDG 6.1, emphasising its link to many others

Appendix 2 – SLR Analysis of Data with Derived Emerging Propositions

The nodal structure shown at Figure 15 is expanded below in Table 39 and illustrates the evolving propositions emanating from the SLR findings. This gives insight into the research issues in column 'b' and the context variables in column 'c', with emerging propositions (high, medium, low) shown in column 'e'. These issues and variables were used to shape the evolving evidence-based framework for structuring the MISI research.

Table 39: MISI SLR Research Findings (issues & variables) from the top 13 articles, leading to emerging propositions.

Authors (a)	MISI Research Issue (b)	Context Variables (c)	Research Issues and thematics extracted from the selected most relevant (based on keyword occurrence articles) (d)	Emerging Proposition Strength (e) (High, Med, Low)
Hall R.P., Ranganathan S., Raj Kumar G.C.	Cascading from Global to the local level	Policy to Implementation	· The challenge now facing development organisations and governments is how to operationalise this interconnected set of goals and targets through effective projects and programmes.	**High**: core to the global-to-local research
		Micro-level OPM modelling approach	· The research indicates a micro-level modelling approach that can quantitatively assess the impacts associated with rural water interventions that are tailored to specific communities.	**Med**: consider use of a water-based case study
			· The multilevel modelling framework provides a generalisable template that can be used in multiple sectors	**High**: aim for multi sector value
Dean K., Trillo C., Bichard E.	Definition and evaluation of Project Success	Inclusion of socio-economic assessment	· Current evaluative methods that support decision making on social housing interventions fail to capture all of the socio-environmental value contained in the UN SDG 11.	**High**: balance of TBL – eg include social
			· The paper addresses the issue by demonstrating how Sustainable Return on Investment can successfully describe and analyse a range of externalities related to the sustainable value generated by social housing regeneration schemes.	**High**: aim for prototype that informs investment decisions
		Inclusion of environmental and socio-economic assessment	· The findings show that, historically, the environmental and social value of regeneration schemes have been largely disregarded because of a gap in the evaluation methods, and that there is room for significant improvement for future evaluation exercises.	**High**: balance of TBL – eg include social, env and econ

Goel A., Ganesh L.S., Kaur A.	Sustainable Construction	Lack of relevant research for project levels	· There is a lack of studies that synthesize and critically evaluate the available literature to provide an overview of the current state of sustainable construction (SC) research in India and provide directions for future research	**Low**: not core to research
		Lack of relevant research for project levels	· Current SC research endeavours are predominantly oriented towards the macro-industry level, the environmental dimension and the internal stakeholders.	**Med**: incl. micro project level
		Outputs versus outcomes success	· Additionally, more emphasis has been provided on the final project deliverable compared to the project processes.	**High**: include Theory of Change
		Research approach	· Overall, this study makes three specific contributions [of which the first two are]: i) the current thrust areas of SC research in India have been identified while pointing out the imbalance in this academic pursuit; ii) a deductive content analysis framework has been developed that provides a generic template for conducting similar SLRs in the context of other countries	**Med**: informs design of the prototype and testing propositions
Zhang L., Chu Z., He Q., Zhai P.	Application of BIM technology for sustainability	Challenges to delivery of sustainability	· Conducted a questionnaire survey with 389 respondents to investigate the applications of BIM technology in sustainable building projects. The results showed that there were four main constraining factors: "Public participation", "technology application", "economic cost", and "application management" "public participation" was particularly important.	**High**: assists the design of the first proposition to test engineer's views
		Opportunities for delivery of sustainability	· The study offers practical and managerial implications based on the findings for local government and the private sector	**Med**: value of MISI application
Dushenko M., Bjorbaek C.T., Steger-Jensen K.	Practical application of Theoretical sustainability models	Limitations of theoretical models	· When documenting a sustainable design of port projects, decision-makers use theoretical sustainability models to conceptualize features of a sustainable society. However, a major challenge for the decision-makers was that the sustainability assessment results did not show, as expected, the same results as those of three existing theoretical sustainability models.	**High**: need for practical models – informs the testing of propositions for practicality
			· The benchmark results indicate a disparity between the importance of what sustainability models describe and what is important in practice.	**High**: as above
Terrapon-Pfaff J., Ortiz W., Dienst C., Gröne M.-C.	Cascading from Global to the local level	Policy to Implementation	· Until now, the focus of WEF [water-energy-food] nexus discussions and applications has mainly been on national or global levels, macro-level drivers, material flows and large Infrastructure developments. This overlooks the fact that major nexus challenges are faced at local level.	**High**: links to the global-to-local thematic

		Micro-level OPM modelling approach	· The study identifies the complex links which exist between sustainable energy projects and the food and water sectors and highlights that these needs are currently not systematically integrated into project design or project evaluation.	**High**: as above
		Outputs versus outcomes success	· A more systematic approach, integrating the water and food pillars into energy planning at local level in the global south, is recommended to avoid trade-offs and enhance the development outcomes and impacts of energy projects.	**High**: include Theory of Change in proposition structure
Schwanitz V.J., Wierling A., Shah P.	Definition and evaluation of Project Success	Policy to Implementation	· Apply a range of assessment methods and study their usefulness as tools to identify trade-offs and to compare the sustainability performance. We calculate cross-sectoral footprints, self-sufficiency ratios and perform a simplified Energy-Water-Food nexus analysis.	**Med**: as above
		Outputs versus outcomes success	· We recommend a general upgrade to indicators and visualization methods that look beyond averages and a fostering of infrastructure for data on sustainable development based on harmonized international protocols.	**Low**: possibly include Theory of Change in proposition structure
		Research approach	· We warn against rankings of countries or regions based on benchmarks that are neither theory-driven nor location-specific.	**Low**: not applicable to study
Diaz-Sarachaga J.M., Jato-Espino D., Castro-Fresno D.	Definition and evaluation of Project Success	Policy to Implementation	· Green rating systems have been launched during the last decades to facilitate the assessment of sustainable development in terms of building and infrastructure, including the evaluation of sustainable urban development through the study of communities. The absence of metrics in the New Urban Agenda led to relate its commitments to the SDGs, which revealed that the prerequisites and credits included in LEED ND and Envision mainly focused on managerial and environmental aspects and disregarded the economic and social dimensions. Consequently, the premises under which LEED ND and Envision were developed must be updated and complemented with the two latest guidelines recently adopted by the United Nations in the field of urban and sustainable development.	**High**: aim for testing use of existing sustainability measurement at project and organisational levels
Sperling J., Romero-Lankao P., Beig G.	Cascading from Global to the local level	Policy to Implementation	· With growing discussion and tensions surrounding the new urban sustainable development goal, announced by the UN in late September 2015, and a new global urban agenda document to be agreed upon at 'Habitat III', issues on whether sustainable urbanization priorities should be set at the international, national or local level remain controversial.	**High**: core to the global-to-local research

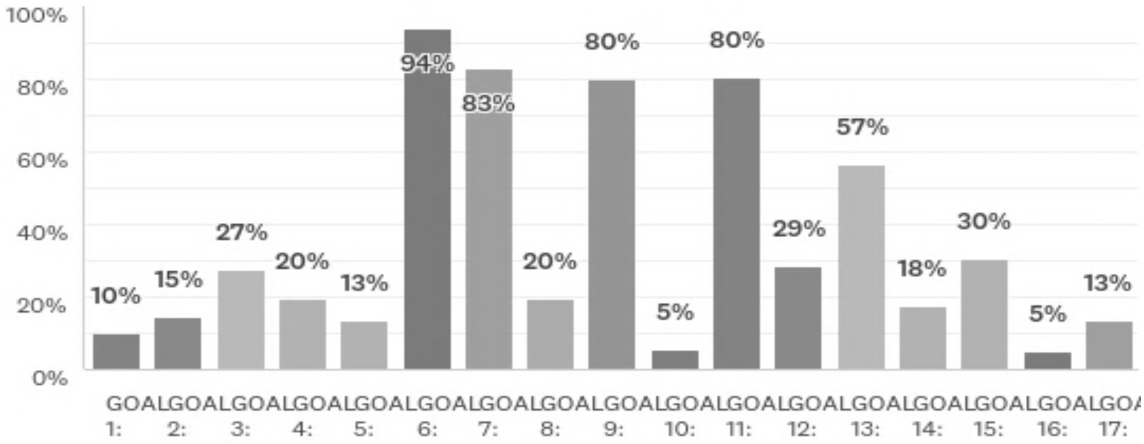
		Micro-level OPM modelling approach	· As such, this study aims to first understand determinants of and variations in local priorities across one city, with implications discussed for local-to-global urban sustainability.	**High**: core to the global-to-local research
Aust V., Morais A.I., Pinto I.	Investment priorities in SDG	Policy to Implementation	· The public and the private sectors play fundamental roles in mobilizing capital to achieve the 2030 Agenda of Sustainable Development. In particular, developing countries can benefit from foreign direct investment (FDI) as a source of external financing in the private sector. This study aims to investigate whether FDI contributes to the achievement of Sustainable Development Goals (SDGs) in Africa. We analyse a sample of 44 African countries regarding their SDG scores and apply a multivariate analysis and an ordered profit model.	**Low**: not core to study but of interest for future research topics and themes
		Opportunities for delivery of sustainability	· Our results indicate that the presence of foreign investors positively influences SDG scores.	**Low**: not applicable to this study
		Challenges to delivery of sustainability	· However, although FDI has a positive impact in areas such as basic infrastructure, clean water, sanitation, and renewable energy, some adverse environmental consequences may occur for host countries. In fact, the relationship between FDI and the probability of achieving SDG13 (Climate action) is negative.	**Low**: as above
		Policy to Implementation	· This study contributes to the literature on sustainable development and can be useful for decision-makers in developing investment plans to support the achievement of SDGs.	**High**: aim for prototype that informs investment decisions
		Policy to Implementation	· Furthermore, we provide evidence of a positive influence of FDI on the SDGs, which might encourage further investments in Africa.	**Low**: not applicable to this study
Di Vaio A., Varriale L.	Investment priorities in SDG	Policy to Implementation	· This article investigates the 17 Sustainable Development Goals (SDGs) Agenda introduced by the United Nations in 2015 outlining if and which organisational, accounting and reporting practices are adopted to sustainable performance. Specifically, adopting the sustainability disclosure framework, we analyse how firms within the airport industry achieve the SDGs 11 and 17 showing how the initiatives are developed and implemented.	**High**: aim for prototype that informs investment decisions
		Research approach	· The article conducts a qualitative study through the reading and processing of financial statements and non-financial reports (sustainability and social reporting) of seven major strategic airport infrastructures in Italy to outline the initiatives implemented for meeting the SDGs.	**Med**: include in Theory of Change proposition structure

		Opportunities for delivery of sustainability	· This article outlines the need to create conditions for developing and better implementing the accounting and reporting practices, like the SBSC (Sustainable Balanced Scorecard), as well as adequate organisational architectures and educational training and management programs for achieving the SDGs goals within firms.	**Med**: as above
da Silva L., Marques Prietto P.D., Pavan Korf E.	Definition and evaluation of Project Success	Policy to Implementation	· This work aimed to select a relevant set of sustainability indicators to analyse municipal solid waste management (MSWM) in large and medium-sized worldwide cities and to apply these findings in three municipalities located in the state of Rio Grande do Sul, in southern Brazil.	**Med**: include in Theory of Change proposition structure
		Policy to Implementation	· The result was the selection of a set of 49 indicators for application in a case study. It was only possible to measure 11 indicators with the information publicly available for the three Brazilian cities studied, demonstrating the fragility of information regarding sustainability issues.	**Low**: as above
		Challenges to delivery of sustainability	· Also, data related to social issues and natural and energy resources were insufficient for indicators to be measured. The analysis revealed difficulties regarding the availability of information in database	**Med**: include in Theory of Change proposition structure
Munyasya B.M., Chileshe N.	Drivers of Sustainable Infrastructure	Opportunities for delivery of sustainability	· While there is a plethora of studies around sustainable infrastructure, there are limited studies undertaken on the influencing drivers and barriers particularly within the South Australian construction industry.	**High**: include in proposition on SWOT of engineers and CEOs
		Challenges to delivery of sustainability	· "Lack of steering mechanism", "multi-disciplinary nature of the word "sustainability", and "lack of cooperation and networking" were the critical barriers.	**Low**: included in SLR

Appendix 3 - Survey questions and selection of the type of question and metric to align with analysis requirements for measuring engineers' views on projects' SDG impact

Q#	Theme	Question	Measuring Value				
			Y / No	1 to 6	text	List	option
	Opening Page	With ICE and GEC logos. Thank the respondent for their time. Explain the purpose of the survey. Who is it for? How long will it take (10 mins)? What will happen with the data? Who is the POC at ICE.					
a		**Are you completing this survey as an individual or for an engineering firm?**					allow single choice for either individual or as engineering firm
1a	Engineering Organisation - General Data on your organisation						
1.1		**Q: What is the name of your organisation.**					complete text
1.2		**Q: In which country is your organisation based?**					text for country and list for continets
1.3		**Q: Name of person completing Survey for firm**					complete text
1.4		**Q: Your role/grade**					complete text
1.5		**Q: Contact details (email)**					complete text
1.6		**Q: Number of Engineers in your firm**					options include 1-49; 50-99, 100 +etc
1.7		**Q: Number of current engineering projects underway (from design through to completion)**					options include 1-20; 20-49; 50-99, 100 +etc
1.8		**Q: In which countries do you deliver projects?**					just home country; 2-5 countries; 6-20 countries; 20+ countries
1.9		**Q: Who is the company's SDG or CSR lead?**					complete text
2	Engineering Organisation - SDG Data on your organisation						
2.1		**Q. How do you plan to assess your impact on the SDGs?** 1 We have no intention to assess our impact on the SDGs 2 We plan to assess our impact on the SDGs but have not thought through how 3 We plan to assess our impact on some of the SDGs and indicators relevant to our business 4 We plan to assess our impact on all the SDGs and indicators relevant to our business 5 We plan to assess our impact on all 17 SDGs and indicators 6 Don't know					select one of the six choices
2.2		**Q. We fully understand the SDG priorities of the governments in our key markets and countries of operation.**					1=strongly agree; 2=agree; 3= neither agree or disagree; 4=disagree; 5=strongly disagree 6=n/a
2.3		**Q. Our company has fully defined the tools that will help it to assess its impact against the SDGs.**					1=strongly agree; 2=agree; 3= neither agree or disagree; 4=disagree; 5=strongly disagree 6=n/a
2.4		**Q. We can comprehensively report to governments and other key stakeholders on how our company is contributing to SDGs.**					1=strongly agree; 2=agree; 3= neither agree or disagree; 4=disagree; 5=strongly disagree 6=n/a
1b	General SDG Data - as a member of the engineering community						
1.1b		**Q: What is the name of your organisation?**					complete text
1.2b		**Q: In which country is your organisation based?**					text for country and list for continets
1.3b		**Q: Contact details (email) - optional**					complete text
1.4b		**Q: Years of experience as qualified engineer**					options incl eg 1-5; 5-10; 10-15; 15+; n/a
1.5b		**Q: Are you a millenial (born 1980-2000)?**					select Y or N; this allows to filter data to assess any difference between them and others
1.6b		**Q. As an engineer I want to know more about UN's Sustainable Development Goals,and what we are doing to measure our impact against them.**					1=strongly agree; 2=agree; 3= neither agree or disagree; 4=disagree; 5=strongly disagree 6=n/a
3	SDG-Engineering specific Questions						
3.1		**Q. From the list below, please rank the five SDGs where you believe engineers have the greatest impact and opportunity.**					list of all 17 Goals with titles
3.2		**Q. Having read the UN's Sustainable Development Goals, do you agree it is important that engineering business' sign up to these goals?**					1=strongly agree; 2=agree; 3= neither agree or disagree; 4=disagree; 5=strongly disagree 6=n/a
3.3		**Q. There is strong evidence that we have a 'fit for purpose' SDG measuring approach to track our contribution from our projects.**					1=strongly agree; 2=agree; 3= neither agree or disagree; 4=disagree; 5=strongly disagree 6=n/a
3.4		**Q. Commercial realities dictate that you should cherry pick the best SDGs for your business instead of the best ones for the planet.**					1=strongly agree; 2=agree; 3= neither agree or disagree; 4=disagree; 5=strongly disagree 6=n/a
4	GEC related Questions: Engineering Community – Sharing Best Practice	*The Global Engineering Congress is being hosted at the ICE from 22-28 Oct 18 (please see details at: Global Engineering Congress Info*					Global Engineering Congress Info
4.1		**Q. I/we are planning to actively engage with the GEC discussions and support plans to agree and implement a global engineering response roadmap to the SDGs?**					1=strongly agree; 2=agree; 3= neither agree or disagree; 4=disagree; 5=strongly disagree 6=n/a
4.2		**Q. As an engineer, I/we support the Global Engineering Congress' objective to unite the engineering community to agree and mobilise a response roadmap to the UNSDG?**					1=strongly agree; 2=agree; 3= neither agree or disagree; 4=disagree; 5=strongly disagree 6=n/a
4.3		**Q. We should look to engineering associations and standards bodies for advice, support and guidance on measuring project contribution to specific SDGs.**					1=strongly agree; 2=agree; 3= neither agree or disagree; 4=disagree; 5=strongly disagree 6=n/a

Appendix 4 - Data capture from survey for question “Select the six SDGs that you believe that engineers have the greatest impact and opportunity”.



GOAL 6: Clean Water and Sanitation - Ensure availability and sustainable management of water and sanitation for all (6)	93%	158
GOAL 7: Affordable and Clean Energy - Ensure access to affordable, reliable, sustainable and modern energy for all (7)	83%	140
GOAL 8: Decent Work and Economic Growth - Promote sustained, inclusive and sustainable economic growth, full and productive employment and decent work for all (8)	19%	32
GOAL 9: Industry, Innovation and Infrastructure - Build resilient infrastructure, promote inclusive and sustainable industrialisation and foster innovation (9)	80%	135
GOAL 10: Reduced Inequality - Reduce inequality within and among countries (10)	5%	9
GOAL 11: Sustainable Cities and Communities - Make cities and human settlements inclusive, safe, resilient and sustainable (11)	80%	136
GOAL 12: Responsible Consumption and Production - Ensure sustainable consumption and production patterns (12)	28%	47
GOAL 13: Climate Action - Take urgent action to combat climate change and its impacts (13)	56%	95
GOAL 14: Life Below Water - Conserve and sustainably use the oceans, seas and marine resources for sustainable development (14)	17%	29
GOAL 15: Life on Land - Protect, restore and promote sustainable use of terrestrial ecosystems, sustainably manage forests, combat desertification, and halt and reverse land degradation and halt biodiversity loss (15)	30%	51
GOAL 16: Peace and Justice Strong Institutions - Promote peaceful and inclusive societies for sustainable development, provide access to justice for all and build effective, accountable and inclusive institutions at all levels (16)	5%	8
GOAL 17: Partnerships to achieve the Goal - Strengthen the means of implementation and revitalise the global partnership for sustainable development (17)	15%	25
Total Respondents: 169		

BASIC STATISTICS

Minimum	Maximum	Median	Mean	Standard Deviation
1.00	17.00	9.00	8.86	3.76

Appendix 5 - Data capture from the survey's Chi-Square Tests (with continuity correction, likelihood ratio, and linear-by-linear association).

Are you a millennial (born between 1980-2000)? * q0023_0001 Crosstabulation

			q0023_0001		
			Agree	Strongly Agree	Total
Are you a millennial (born between 1980-2000)?	Yes	Count	21	2	23
		Expected Count	17.7	5.3	23.0
	No	Count	22	11	33
		Expected Count	25.3	7.7	33.0
Total		Count	43	13	56
		Expected Count	43.0	13.0	56.0

Chi-Square Tests

	Value	df	Asymp. Sig. (2-sided)	Exact Sig. (2-sided)	Exact Sig. (1-sided)
Pearson Chi-Square	4.615[a]	1	.032		
Continuity Correction[b]	3.337	1	.068		
Likelihood Ratio	5.087	1	.024		
Fisher's Exact Test				.052	.031
Linear-by-Linear Association	4.533	1	.033		
N of Valid Cases	56				

a. 0 cells (0.0%) have expected count less than 5. The minimum expected count is 5.34.

b. Computed only for a 2x2 table

Are you a millennial (born between 1980-2000)? * q0024_0001 Crosstabulation

			Total
Are you a millennial (born between 1980-2000)?	Yes	Count	65
		Expected Count	65.0
	No	Count	95
		Expected Count	95.0
Total		Count	160
		Expected Count	160.0

Chi-Square Tests

	Value	df	Asymp. Sig. (2-sided)
Pearson Chi-Square	8.564[a]	5	.128
Likelihood Ratio	9.474	5	.092
Linear-by-Linear Association	4.358	1	.037
N of Valid Cases	160		

a. 2 cells (16.7%) have expected count less than 5. The minimum expected count is .81.

Are you a millennial (born between 1980-2000)? * q0024_0001 Crosstabulation

			q0024_0001		
			Agree	Strongly Agree	Total
Are you a millennial (born between 1980-2000)?	Yes	Count	24	9	65
		Expected Count	21.4	6.2	65.0
	No	Count	28	6	93
		Expected Count	30.6	8.8	93.0
Total		Count	52	15	158
		Expected Count	52.0	15.0	158.0

Chi-Square Tests

	Value	df	Asymp. Sig. (2-sided)
Pearson Chi-Square	7.150[a]	4	.128
Likelihood Ratio	7.372	4	.117
Linear-by-Linear Association	3.358	1	.067
N of Valid Cases	158		

a. 0 cells (0.0%) have expected count less than 5. The minimum expected count is 6.17.

Are you a millennial (born between 1980-2000)? * q0022_0001 Crosstabulation

			q0022_0001		
			Agree	Strongly Agree	Total
Are you a millennial (born between 1980-2000)?	Yes	Count	23	39	62
		Expected Count	27.7	34.3	62.0
	No	Count	39	38	77
		Expected Count	34.3	42.7	77.0
Total		Count	62	77	139
		Expected Count	62.0	77.0	139.0

Chi-Square Tests

	Value	df	Asymp. Sig. (2-sided)	Exact Sig. (2-sided)	Exact Sig. (1-sided)
Pearson Chi-Square	2.553[a]	1	.110		
Continuity Correction[b]	2.034	1	.154		
Likelihood Ratio	2.567	1	.109		
Fisher's Exact Test				.125	.077
Linear-by-Linear Association	2.535	1	.111		
N of Valid Cases	139				

a. 0 cells (0.0%) have expected count less than 5. The minimum expected count is 27.65.

b. Computed only for a 2x2 table

Question 2. We conducted SPSS analysis to ascertain Chi-Square between the two age groups (millennial and non-millennial) and their responses. There were 159 answers that gave a p-value (Pearson Chi-Square) of 0.136. This was not fully statistically significant but indicates a viable trend that might justify further analysis. However, when the optionality of questions was condensed, combining the agree and strongly agree as well as then separately combining the disagree and strongly disagree, then the results became more statistically significant at p-value of 0.110.

Question 3: There was initially a p-value of 0.001, suggesting that the non-millennials were not having any markedly different opinions on the answers to this question. However, when further analysis was conducted by combining agree and strongly agree, the p-value was 0.032, indicating that the Millennials had similar numbers agreeing but a much higher proportion of millennials were strongly agreeing. It is difficult to interpret what this categorically means but it could indicate that there is likely to be a stronger viewpoint from a generation that prefer to give higher ratings for an issue that has such catastrophic impacts if it is not dealt with effectively.

Appendix 6 - Blog of ICE workshop (between survey and interview stages to validate results) led by Paul Mansell with practitioners & academics at the Institution of Civil Engineers – The 'Control Group'

Written by the Head of Knowledge at the ICE – Elodie Huiban, published 1 May 2019:

Measuring SDG impact across Infrastructure projects Workshop – 25th April 2019 @ ICE

If the global engineering congress enthused more than 3500 engineers worldwide last October, the engineering community is still asking itself: ***how do we translate high level goals to project context?*** *And since what can't be measured can't be managed it feels like the most important task on our to-do list post-congress.*

ICE dedicated some time to this question at a workshop with a cross section of practitioners, academics and other thought leaders on ***Measuring SDG Impact across Infrastructure Projects****.*

Why?
The construction industry has a major role in achieving measurable impact against the Sustainable Development Goals 2030 targets. The estimated USD $94 trillion (Global Infrastructure Hub, 2017 & 2018) of investment in infrastructure projects that is required globally by 2040, represents a massive opportunity to stimulate economic prosperity, reduce poverty and raise standards in health, education and gender equality.

However, the linking of infrastructure project success to SDG targets is problematic as a recent Institution of Civil Engineers' survey led by Paul Mansell in 2018 demonstrated: whilst the appetite for SDG reporting at project level is very strong (87%), especially by millennials, only a third of the 325 respondents assessed current tools as 'fit for purpose'.

What?
ICE brought a group of like-minded partners together to share the latest research on sustainability measurements methods at organisational and project level. We did a lot of listening in the morning and utilised those methods to inform practical exercises throughout the afternoon.

1. ***Nathu Puri Institute for Engineering and Enterprise / London South Bank University***

Paul Mansell, a Doctoral Researcher who is working closely with ICE to transform the way engineers engage with SDGs presented his latest research focused on finding methods that will help engineers and engineering firms to demonstrate SDG impact across infrastructure projects
>> ***Sharing empirical evidence of a 'golden thread' from project level SDG reporting to organisational level***

As Paul has demonstrated throughout his research ***linking infrastructure project sustainability performance to Sustainable Development Goals (SDG) targets is problematic****. Through his doctoral research, a new Infrastructure Project Transformation Process Model is being proposed, called the 'Infrastructure SDG Impact-Value Chain'(IVC) to link tactical-level project delivery with global-level strategic SDG impacts. He demonstrated the viability of this method using a water utility company case study to showcase how the model can integrate the 'Triple Bottom Line' to ensure balanced definition of success across economic, environmental and social thematic areas. The proposed methodology aimed at project leaders enables stakeholders' alignment on a common definition of project success during the design phase. It includes selection of longer-term outcomes and strategic SDG impacts.*

Having assessed several sustainability measurement tools and methodologies including the UN Global Compact Compass; GRI and CEEQUAL, Paul outlined that only 9% of the 232 SDG indicators are highly relevant to engineering projects, which poses the crucial question ***what set of specific***

infrastructure indicators (not SDG indicators) can project leaders choose from that are relevant for infrastructure projects?

Closely related is the Inclusive growth agenda, which has the combined purpose of ensuring increased prosperity with greater equity and improved wellbeing and living standards. Richard suggested that the focus of all project leaders should be to find monetary value to improving peoples' lives by understanding which project options deliver greater net benefit.

Engineering projects must move away from the traditional cost benefit model and put environmental and social bottom line on the same pedestal as economical drivers. Most engineering projects impacts might not be financial. A Social value analysis allows for the total value created by projects to be measured in a common currency using techniques endorsed by HM Treasury and the OECD.

Throughout the day, the energy in the room was high, valuable conversations took place and the participants discussed their understanding of the interconnections between SDGs and appreciated the sheer complexity of choosing between 17 SDGs, 169 targets or 232 indicators at project level.

How?
After lunch, participants were asked to validate and test some of the research presented in the morning whilst assessing the feasibility of doing such exercise with project teams.

Paul presented us with a series of cards representing the SDGs and another set representing the 169 targets so we could choose a set of primary and secondary SDGs to prioritise for the development of an infrastructure project that is seeking to provide safe drinking water to a village in Zambia. Once we prioritized our SDGs we drew lines between the SDGs to build a nexus map of interactions and analyzed our network, by quantitative scoring to identify relationship strengths between SDGs.

SDG PRIORITIES
The 3 groups had different approaches and chose different SDGs as priorities, whilst all groups included SDG6 Clean water and sanitation and SDG3 Good health and wellbeing (as the 2 most obvious ones) the other SDGs were different from one group to another, choosing SDG 13 Climate action over SDG8 Decent work and economic growth or SDG2 no hunger – the links between our project and those SDGs were not as clear and when we delved into the targets, it got even more complicated…

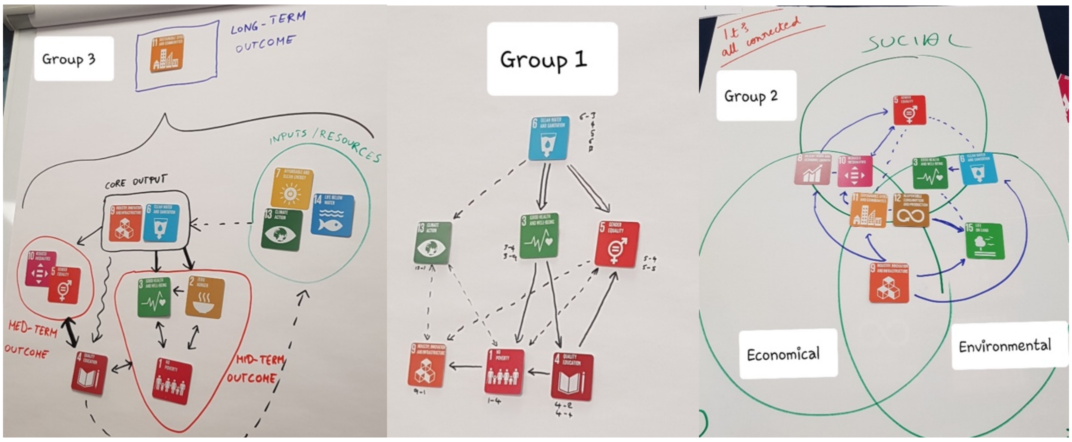
We felt empowered by discovering more about each SDG we had chosen to prioritise for the project and yet challenged by the urge to want to know more about each target to ensure the project will achieve its priority SDG and be measured against its indicators.
At that point most of us were overwhelmed by the nature of the 232 indicators which sits underneath the 17 SDGs and its 169 targets.

Another realisation occurred – no one from a project team will go through all of the above in great detail – it's too complex, time consuming and indicators are inappropriately applicable to a project or possible to easily integrate as part of measurement tools.

It highlights again the need for the engineering industry to agree on how SDG targets/indicators should be translated from high level goal to project context – and ICE is forming a ***working group on Measuring, Monitoring and Reporting impact against SDGs across infrastructure projects*** *to further develop methods to answer this apparent need.*

SDG SYSTEM MAP OF INTERDEPENDENCIES

Finally, each group built a generic Infrastructure SDG system map of interdependencies between the SDG chosen as priorities which could be used at the project design stage to effectively assess pre and post-project success as defined within the IVC model presented and developed by Paul and piloted throughout the afternoon.



NEXT STEPS

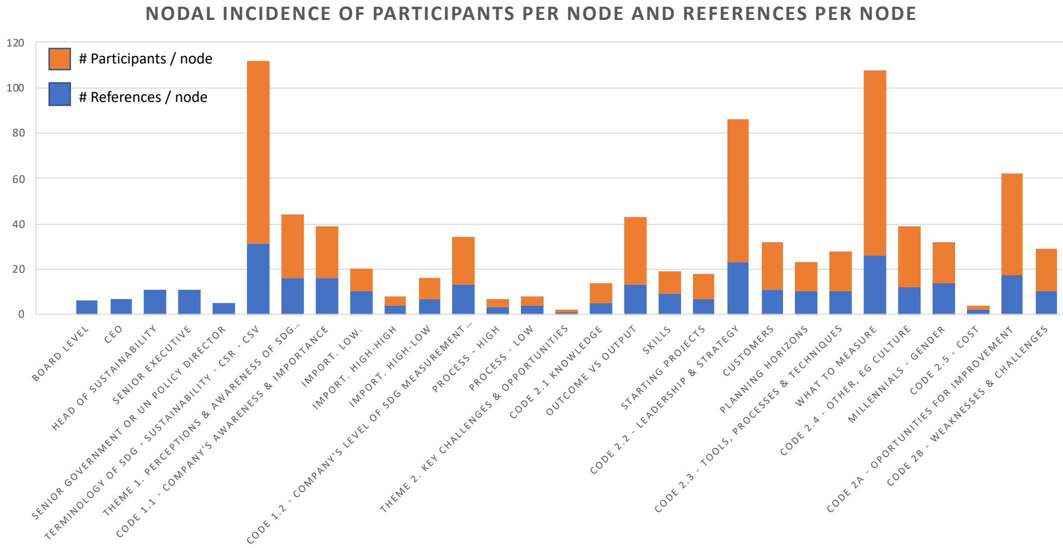
To conclude we assessed our achievements throughout the day and discussed next steps.

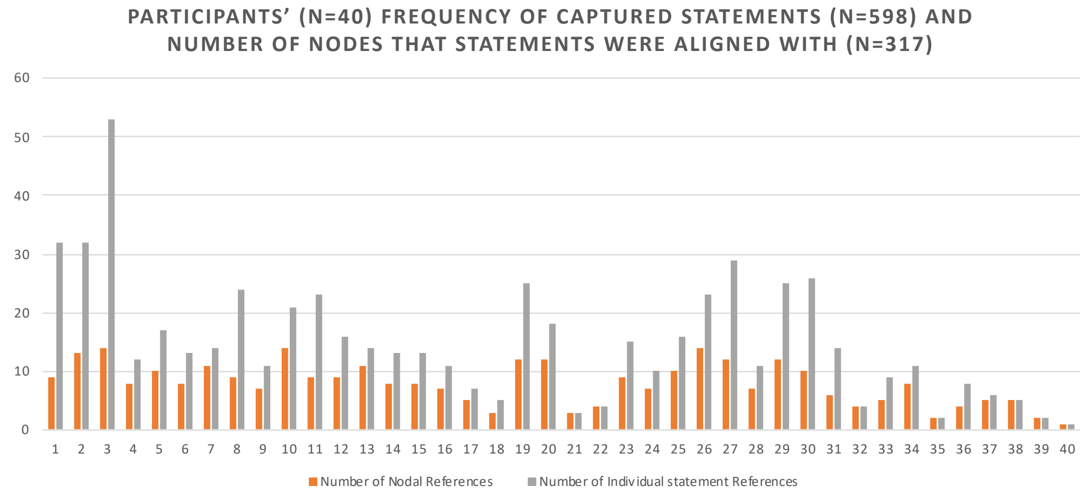
1. *Set further discussions and workshops on translating high level goals to project context to find out how:*
    a. *To standardise and consistently use which metrics to report on and how do you collect it?*
    b. *Create a central repository of all projects above 50 million pounds which will demonstrate SDGs alignment and enable progress on the below*
    c. *Identify benefits of building SDGs into your project = to incentivise and build a strong business case*
    d. *Test bed a pilot repository (Starting with assessing DFID global infrastructure programme open data information) which could lead to an open data platform of SDG realisation on projects globally*
    e. *Use this workshop/game approach to further educate the workforce*
2. *How could these methods inform/influence the selection of projects and empower project teams to create the winning business case (this is the major gap identified in the industry at the moment)*

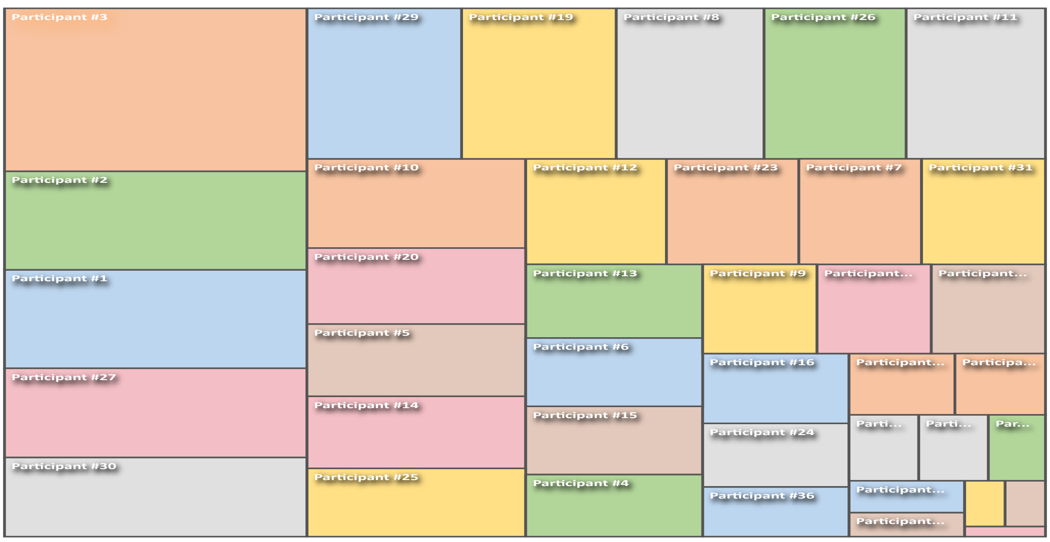
Appendix 7 – List of Interviewees and company background data

	Role		Organisation							Interview data				Awareness Vs capability		Transcription Project	
Participant ID	Role	Management Cat	Organisation		Size (FTE)	Size Category (>50; 25-50;10-25;<10;other)	Share value	Global / National	Geography of Business Category	Interview date	Interview length	Words transcribed	joint or Individual	Three level of SDG focus awareness Vs application	Level of Self-assessed Capability / Maturity 1-5	Transcripted	Nvivo coding completed
1	Past President ICE; Chair of Construction & Infrastructure Policy;	Board	UCL BSC&PM	n/a	n/a	other	n/a	n/a	Other	**1.30pm 3 July**	45	4,752	Individual	n/a	n/a	yes	yes
2	Global Sustainability Leader	Senior Executive	MottMac	multidisciplinary consultancy; one of the largest employee-owned companies in the world. About 16,000 projects per year	16,000	10-25k		150 countries	Global	**11am 4 July**	55	5,892	Individual	3 = aware and doing it	2 - early processes in place	yes	yes
3	UK Director of Sustainability	Head of Sustainability	WSP	Design, Engineering consulting, Environmental consulting, Planning, Professional services	48,000	25-50k	Revenue C$6.4 Bn in 2016	offices in 50 countries	Global	**3pm 4 July**	61	7,177	Individual	3 = aware and doing it	3 - using sustainable process	yes	yes
4	CEO	CEO	Capita Symonds	UK multidisciplinary consultancy operating in the building design, civil engineering, environment, management and transport sectors, part of the Capita Group.	2,000 staff with contractors of total of c4500	<10k		Capita Group has 4,500 staff in 50 offices across UK and Ireland	Regional	**10am 10 July**	42	5,508	Individual	2 = aware and not doing it	1 - basic level at definition stage	yes	yes
5	CEO	CEO	BAM Nuttall	A construction and civil engineering company HQ in Camberley, UK. Involved in a portfolio of road, rail, nuclear, and other major projects worldwide. Subsidiary of the Dutch Royal BAM Group.	3,100 in UK at 120 sites of 25,000 in Group	<10k	£674 m turnover in 2017		Regional	**9am 1 August**	53	4,923	Joint	3 = aware and doing it	2 - early processes in place	yes	yes
6	People & Culture Director	Senior Executive	BAM Nuttall	ditto	ditto	<10k	ditto	ditto	Regional	**9am 1 August**	53		Joint	3 = aware and doing it	2 - early processes in place	yes	yes
7	Chief Exec Environment & Ground Engineering	CEO	AECOM	AECOM is an American multi-national engineering firm. #164 in Fortune 500 in 2018. focusing on all aspects of the environmental consultancy which is contaminated land to environmental access, social impact assessment, noise and air quality of the whole gamut	1,600 in 50 countris within business of 87000	>50k	$21 Bn in 2018	Global	Global	**1pm 10 July**	40	4,222	Individual	1 = unaware and not doing it	0 - processes not developed	yes	yes
8	CEO	CEO	Crossrail	Crossrail is the name of the rail construction project and of the limited company, wholly owned by TfL, that was formed to carry out construction works. ... Crossrail, rebranded as the Elizabeth line, is currently planned to come into full service with an east-west service across central London in late 2019.	supported 55,000 jobs	<10k			National	**10am 23 July**	42	5,324	Individual	2 = aware and not doing it	0 - processes not developed	yes	yes
9	Head of Sustainability	Head of Sustainability	Anglian Water	Anglian Water is a water company that operates in the East of England. Anglian Water is regulated under the United Kingdom Water Industry Act 1991.	4,000	<10k	Revenue in 2015 was £1244 M	UK and Netherlands	National	**9am 10 July**	36	3,105	Individual	3 = aware and doing it	2 - early processes in place	yes	yes
10	Director of Strategy & Investment	Senior Government or UN Policy Director	Environment Agency	The Environment Agency (EA) is a non-departmental public body, established in 1995 and sponsored by the United Kingdom government's Department for Environment, Food and Rural Affairs (DEFRA), with responsibilities relating to the protection and enhancement of the environment in England. "we have 1000s of projects ongoing at any one	11,200	<10k	8 directorates	England	National	**4pm 4 July**	52	5,643	Individual	2 = aware and not doing it	1 - basic level at definition stage	yes	yes
11	Director of Asset Management	Senior Executive	Anglian Water	Anglian Water is a water company that operates in the East of England. Anglian Water is regulated under the United Kingdom Water Industry Act 1991.	4,000	<10k	Revenue in 2015 was £1244 M	UK and Netherlands	National	**9am 10 July**	36	3,307	Individual	3 = aware and doing it	2 - early processes in place	yes	yes
12	Expansion Programme Director	CEO	Heathrow	Heathrow expansion is a project in the national interest, which will help deliver new domestic routes and connect more of the country to fast growing markets around the world.	76,000 work at LHR. Increase to 180,000	<10k		UK	National	**4pm 1 August**	35	3,458	Individual	3 = aware and doing it	2 - early processes in place	yes	yes
13	Technical Director	Senior Executive	Crossrail	see above	supported 55,000 jobs	<10k		UK	National	**10am 23 July**	42	5,435	Individual	2 = aware and not doing it	0 - processes not developed	yes	yes
14	Managing Director of Partnership	CEO	the @One Alliance - Anglian	What the @one Alliance does for Anglian Water. The @one Alliance is a collaborative, virtual joint venture formed to deliver the large part of the Anglian Water capital investment programmes.	n/a	<10k	n/a	UK	National	**1pm 13 August**	52	5,231	Individual	3 = aware and doing it	1 - basic level at definition stage	yes	yes
15	Sustainability Director	Head of Sustainability	Mace	privately owned company that does not have shareholder pressure to perform in a certain way.	5,042 (2017)	<10k	Revenue £2,037 (2017)	UK	Global	**3pm 10 July**	56	5,838	Joint	2 = aware and not doing it	1 - basic level at definition stage	yes	yes
16	Gp FD	Board	Mace	Mace Group Ltd, commonly known as Mace, is a global consultancy and construction firm headquartered in London	5,042 (2017)	<10k	Revenue £2,037 (2017)	UK	Global	**3pm 10 July**	56		Joint	3 = aware and doing it	1 - basic level at definition stage	yes	yes
17	Partner for Sustainability	Senior Executive	Deloitte	Deloitte, is a multinational professional services network. Deloitte is one of the "Big Four" accounting organizations and the largest professional services network in the world by revenue and number of professionals.	286,200 (2018) global	>50k	Revenue US$ 43.2 Bn (2018)	Global	Global	**12.00 12 July**	21	2,731	Individual	3 = aware and doing it	2 - early processes in place	yes	yes
18	Infrastructure & Materials	Senior Government or UN Policy Director	BEIS	The Department for Business, Energy and Industrial Strategy (BEIS) is a department of the government of the United Kingdom, which was created on 14 July 2016		other	Annual Budget £13.8 Bn (2016-17)		Other	**11am 10 July**	36	3,452	Individual	n/a	n/a	yes	yes
19	Global Sustainable Development Leader	Head of Sustainability	Arup	Arup (officially Arup Group Limited) is a multinational professional services firm headquartered in London which provides engineering, design, planning, project management and consulting services for all aspects of the built environment. It is a Trust owned company.	13,840 (2018)	10-25k	Revenue £1.56 Bn (2018)	90 offices in 35 countries. Arup has participated in projects in over 160 countries.	Global	**5pm 10 July**	75	9,146	Individual	3 = aware and doing it	3 - using sustainable process	yes	yes
20	Design Delivery Manager, HS2 Curzon Street Station	Head of Sustainability	WSP	Design, Engineering consulting, Environmental consulting, Planning, Professional services	48,000	10-25k	Revenue C$6.4 Bn in 2016	offices in 50 countries	Global	**11am 16 July**	55	4,903	Individual	3 = aware and doing it	3 - using sustainable process	yes	yes
21	General Counsel, Exec Board member	Board	Galliford Try	Galliford Try plc is a British construction and house-building company registered in Uxbridge, London. Founded 1908	5,485 (2018)	<10k	Revenue £2,932 (2018)		Regional	**2pm 12 July**	45	4,069	Joint	2 = aware and not doing it	1 - basic level at definition stage	yes	yes
22	Head of Communications	Head of Sustainability	Galliford Try	ditto	ditto	<10k	ditto	ditto	Regional	**2pm 12 July**	45		Joint	2 = aware and not doing it	1 - basic level at definition stage	yes	yes
23	Head of Environmental Sustainability	Head of Sustainability	Laing O'Rourke	Laing O'Rourke is a multinational construction company headquartered in Dartford, UK. It was founded in 1978 by Ray O'Rourke. It is the	12,796 (2017/18)	10-25k	£2,928.9 million (2017/18)		Global	**11am 17 July**	45	4,393	Individual	2 = aware and not doing it	0 - processes not developed	yes	yes
24	Head of Infrastructure	Senior Executive	Pinsent Masons	Pinsent Masons LLP is an international law firm which specialises in the energy, infrastructure, financial services, real estate and advanced manufacturing and technology sectors. The firm ranks among the top hundred law firms in the world by	2,500	<10k	£432.1 million (2016/17)	25 offices in UK, 400 partners; legal team of c1,800 and over 2,500 staff	Global	**11am 13 July**	39	3,289	Individual	2 = aware and not doing it	0 - processes not developed	yes	yes
25	Director, Electricity Transmission Owner	Senior Executive	National Grid	National Grid plc is a British multinational electricity and gas utility company headquartered in Warwick, UK. Its principal activities are in the UK and NE US. founded 1990.	22,600 (2018)	10-25k	Revenue £15.25 Bn (2018)		National	**12.30 14 August**	43	5,027	Individual	3 = aware and doing it	1 - basic level at definition stage	yes	yes
26	Head of IPM Strategic Initiatives, Infrastructure and Project Management Group	Senior Government or UN Policy Director	UNOPS	UNOPS implements more than $1 billion worth of peace and security, humanitarian and development projects for its partners every year,	600 open projects at the moment	<10k	400 to 500 million a year	operating in more than 80 countries.	Global	**9am 2 July**	38	3,458	Individual	2 = aware and not doing it	1 - basic level at definition stage	yes	yes
27	Acting Head, Prosperity Fund, Joint Funds Unit	Senior Government or UN Policy Director	FCO - Prosperity Fund	The £1.2 billion Prosperity Fund operating until 2023, across: investment in infrastructure and human capital;innovation and technology; increasing trade; financial and economic reform; and ease of doing business.	n/a	other	n/a	n/a	National	**12.00 18 July, FCO**	47	4,147	Individual	3 = aware and doing it	2 - early processes in place	yes	yes
28	Leader Infrastructure Design Gp	Senior Executive	Arup	Arup (officially Arup Group Limited) is a multinational professional services firm headquartered in London which provides engineering, design, planning, project management and consulting services for all aspects of the built environment. It is a Trust owned company.	13,840 (2018)	10-25k	Revenue £1.56 Bn (2018)	90 offices in 35 countries. Arup has participated in projects in over 160 countries.	Global	**5.30pm 23 July**	36	3,125	Individual	3 = aware and doing it	2 - early processes put in place as trial	yes	yes
29	Environmental Sustainability Manager	Head of Sustainability	National Grid	National Grid plc is a British multinational electricity and gas utility company headquartered in Warwick, UK. Its principal activities are in the UK and NE US. founded 1990.	22,600 (2018)	10-25k	Revenue £15.25 Bn (2018)		National	**2pm 17 July**	46	5,743	Individual	2 = aware and not doing it	1 - basic level at definition stage	yes	yes
30	Infrastructure Leadership Council; chair the government construction board; green construction board, as part of leadership council;	Senior Government or UN Policy Director	Infrastructure and Projects Authority, Cabinet Office, UK Government	The Infrastructure and Projects Authority (IPA) is the United Kingdom government's centre of expertise for infrastructure and major projects. The IPA sits at the heart of government, reporting to the Cabinet Office and HM Treasury. The core teams include experts in infrastructure, project delivery and project	n/a	other	n/a	n/a	Other	**4pm 6 July**	65	7,052	Individual	2 = aware and not doing it	0 - processes not developed	yes	yes
31	Vice President, Strategy and Partnership, GEC speaker	Senior Executive	Engineers Canada	n/a	n/a	<10k	n/a	n/a	National	**9am EST/2pm BST 14 Aug**	59	7,422	Joint	n/a	n/a	yes	yes
32	Vice President, Strategy and Partnership, GEC speaker	Senior Executive	Engineers Canada	n/a	n/a	<10k	n/a	n/a	National	**9am EST/2pm BST 14 Aug**	59		Joint	n/a	n/a	yes	yes
33	Head of Sustainability	Head of Sustainability	United Utilities	United Utilities Group plc (UU), the United Kingdom's largest listed water company, was founded in 1995 as a result of the merger of North West Water and NORWEB. The group manages the regulated water and waste water network in North West England, which includes Cumbria, Cheshire, Greater Manchester, Lancashire and Merseyside, which have a combined population of		10-25k	£1,735.8 million (2018)		Global	**10am 23 July**	lost	lost	individual	2 = aware and not doing it	1 - basic level at definition stage	lost	yes
34	Head of Sustainability	Head of Sustainability	Network Rail	Network Rail is the owner (via its subsidiary Network Rail Infrastructure Ltd, which was known as Railtrack plc before 2002 and infrastructure manager of most of the railway network in Great Britain.	37,000	10-25k	£6.2 billion (2013)		National	**12.30am 23 July**	44	3,976	joint	2 = aware and not doing it	1 - basic level at definition stage	yes	yes
35	Group Director of Safety, Technical & Engineering	Board	Network Rail	ditto ... Network Rail is an arm's length public body of the Department for Transport with no shareholders, which reinvests its income in the railways.	ditto	10-25k	ditto		National	**1pm 23 July**	44		joint	2 = aware and not doing it	1 - basic level at definition stage	yes	yes
36	Director – CEEQUAL & Infrastructure	Senior Executive	BRE Group	The Building Research Establishment (BRE) is a centre of building science in the United Kingdom, owned by charitable organisation the BRE Trust. It is a former UK government national laboratory that was privatised in 1997. BRE provides research, advice, training, testing, certification and standards for both public and private sectororganisations in the UK and abroad.	n/a	other	n/a	n/a	Global	**9am 17 Aug**	65	5,480	individual	2 = aware and not doing it	1 - basic level at definition stage	yes	yes
37	Head of Environment and Sustainability	Head of Sustainability	Taylor Woodrow	Taylor Woodrow was one of the largest housebuilding and general construction companies in Britain.	8,132 (2005)	<10k	£3,572.1 million (2006)		Global	**10AM 14 August**	57	4,498	Joint	3 = aware and doing it	1 - basic level at definition stage	yes	yes
38	Head of Environment and Sustainability	Head of Sustainability	Taylor Woodrow	ditto	ditto	<10k	ditto	ditto	Global	**10AM 14 August**	57		Joint	3 = aware and doing it	1 - basic level at definition stage	yes	yes
39	President	CEO	Institution of Engineers, Pakistan	n/a	n/a	other	n/a	n/a	National	**Written responses 13/7**	written	741	Individual	n/a	n/a	n/a	n/a
40		CEO	COIT, Spain (Telecomms)	n/a	n/a	other	n/a	n/a	Global	**Written responses**	written	546	Individual	n/a	n/a	yes	yes
											47	153,013					
											Avg interview length	total words transcribed					

Appendix 8 – Nodal Incidence of participants Per Node and Frequency of Statements Per Node







Appendix 9 - NVivo Codebook of Node Descriptions and Occurrences of Codified Data Collection

Name	Description	Files	References
1. What role and level in the Organisation was the Participant?			
Board Level	The Participant was currently at Board level, or, had recently retired from a similar level role.	6	
CEO	The Participant was had a title of CE, CEO or MD. Their business area was a stand-alone unit that they had P&L accountability for.	7	
Head of Sustainability	They had the primary responsibility for coordinating and managing the company's sustainability approach. None of them had SDG in their job title, although some had SDG in their job description.	11	
Senior Executive	They had an executive role for a discreet business area. Typically had the word Director in their job title.	11	
Senior Government or UN Policy Director	At Director or Deputy Director level in Government departments, or, International Organisation.	5	
2. **Outcome** – how did the organisation identify with SDG outcomes?			
Terminology of SDG - Sustainability - CSR - CSV	After the salutations and clarification of the ethics clearances (eg confirmed that the form had been signed and returned) the interview started with a discussion on their company's use of terminology across sustainability, Sustainable Development, SDG and Corporate Social Responsibility (CSR).	31	81
3. **Mechanism** – how important and advanced was the organisation's SDG measurement?			
Theme 1. Perceptions & Awareness of SDG Measurement	The third area of discussion was for the Participant to self-assess their company's 'Awareness & Application' of SDG measurement and also their assessed level of 'SDG measurement Process Maturity'.	16	28
Code 1.1 - Company's awareness & importance	Self-assess company's 'Awareness & Application' of SDG measurement	16	23
Import. Low.	This banding indicated that the company placed low importance on SDG measurement. They were unaware and didn't apply them.	10	10
Import. High-High	This banding indicated that the company recognised the importance of SDG measurement, and had a high level of engagement with SDGs.	4	4
Import. High-Low	This banding indicated that the company recognised the importance of SDG measurement, but there was low level of engagement with SDGs.	7	9
Code 1.2 - Company's level of SDG Measurement Maturity	Company's self-assessed level of 'SDG measurement Process Maturity'.	13	21
Process - High	This banding indicated that the company had a higher than average maturity of SDG measurement processes: either 2 = early processes in place; 3 = sustainable SDG processes.	3	4
Process - Low	This banding indicated that the company had a higher than average maturity of SDG measurement processes: either 0 = no SDG processess; 1 = currently defining processes.	4	4
4. **Context** – what issues effect (SWOT) the success of SDG measurement?			
Theme 2. Key Challenges & Opportunities	The analysis of the contextual issues that affected companies' ability to measure SDG impacts successfully were captured using a SWOT (strength, weakness, opportunity, threat) approach. There were 5 primary areas of nodes that were derived from the preceding survey of	1	1

Name	Description	Files	References
	325 engineers.		
Code 2.1 Knowledge	The knowledge codes had been identified by the preceding survey of 325 engineers as the single largest factor that negatively impacted SDG measurement at organisational and project levels.	5	9
2.1.1 Outcome Vs Output	Within Code 2.1, the first sub-code was the challenge of differentiating between outputs and outcomes. Too few knew how to do this well and as a result, the wrong 'targets-indicators' were being measured to define success.	13	30
2.1.2 skills	Skills covered a number of areas including: the skills to be able to define success definitions; business skills to be able to build performance frameworks; sustainability/SDG skills that helped understand the SDG framework and how they relate at sub global-national levels, at organisational and project levels.	9	10
2.1.3 starting projects	The preceding survey had not highlighted the importance of 'starting projects well'. This node was added during the interviews since it was often referred to as the 'key investment decision point' and its linkage to SDG impacts.	7	11
Code 2.2 - Leadership & Strategy	The Leadership and Strategy codes had been identified by the preceding survey of 325 engineers as the second highest challenge in SDG measurement at organisational and project levels.	23	63
2.2.1 Stakeholders and customers	The interviews highlighted the importance of understanding the stakeholders. The word analysis categorises a number of stakeholders that were most frequently referred to by the participants, such as: government, communities, investors, users, suppliers etc.	11	21
2.2.2 Planning horizons	There was frequent reference to the need to think longer term. SDGs have targets and goals for 2030, but the references were to moving from short term RoI that were driven by economics only, to a longer term more balanced approach across Environment and society issues. Hence the SDG were viewed as a good way to achieve this ambition.	10	13
Code 2.3 - Tools, Processes & Techniques	The research longer term aim was to assess whether a new approach, by developing existing theory, could be designed to measure SDG with greater success. This led to common reference to the use of tools, systems and methodologies, although at this stage, the interviews did not seek detailed analysis on any specific aspect.	10	18
2.3.1 What to measure	There were many references to what is measured; The selection of targets becomes critical in a business environment that is already awash with data collection. Is it quantitative data or qualitative? What is the balance between too little data collection and too much?	26	82
Code 2.4 - Other, eg Culture	The single most important area for ensuring SDG measurement success is having a successful change programme that ensures a practical approach is made to work for the 'users' with added value of what they are doing.	12	27
2.4.1 Millennials - gender	The preceding survey included a number of specific questions relating to the interests-perceptions-values of millennials. Some consistent and interesting considerations, especially in senior executives recognising the demands of millennials in this area and the need to adjust their approach in consideration of the recruitment and retention HR issues.	14	18
Code 2.5 - Cost	Many participants referred to the realities of ensuring that at the bottom line, businesses remained profitable.	2	2
Code 2a - Opportunities for improvement	This node was a catch-all for the positive suggestions for improving SDG measurement in their organisations.	17	45
Code 2b - Weaknesses & Challenges	This node was a catch-all for the the challenges for improving SDG measurement in their organisations.	10	19

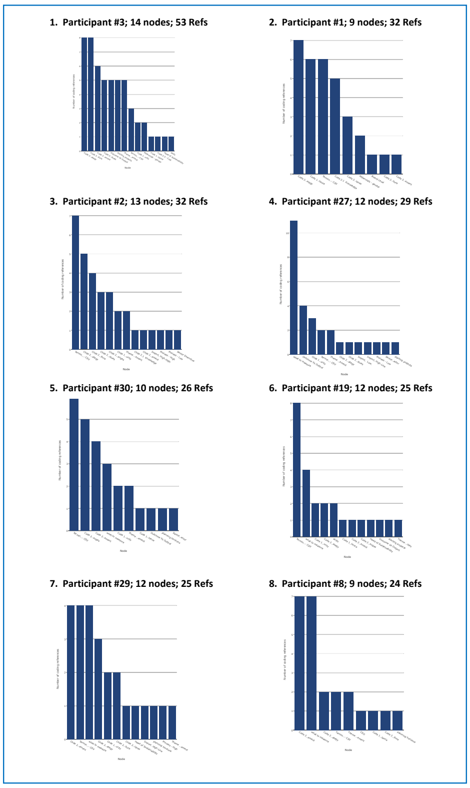
Appendix 10 - Data analysis using NVivo: nodal-word linkages

Category	C-M-O	Sub-Category	Word	Count	f1 Weighted %	f2 %	f3 %
Sustainability; Sustainable Development; SDG	Context	Sustainability	sustainability	377	0.71%	0.71%	2.24%
				377	0.71%		
		Sustainable Development	sustainable	154	0.29%	0.56%	
			development	142	0.27%		
				296	0.56%		
		SDGs	sdgs	328	0.62%	0.97%	
			sdg	188	0.35%		
				516	0.97%		
Triple Bottom Line (TBL)	Outcome	TBL - Social	social	77	0.15%	0.35%	0.68%
			society	49	0.09%		
			csr	59	0.11%		
				185	0.35%		
		TBL - Environment	environment	79	0.15%	0.25%	
			environmental	52	0.10%		
				131	0.25%		
		TBL - Economic	economic	20	0.04%	0.08%	
			Prosperity	19	0.04%		
				39	0.08%		
Theory of Change, (causal logic chain from inpts to impacts)	Mechanism	Input to Activity - 'iron triangle' of cost-time-scope	resources	20	0.04%	0.33%	1.26%
			cost	57	0.11%		
			costs	17	0.03%		
			funding	16	0.03%		
			efficiency	16	0.03%		
			money	18	0.03%		
			commercial	17	0.03%		
			spend	17	0.03%		
		Activity to Output (time, cost, scope)	initiatives	27	0.05%	0.12%	
			activities	15	0.03%		
			outputs	19	0.04%		
		Outcome and benefits delivered outcome is the result of the change derived from using the project's outputs. A benefit is the measurable improvement resulting from an outcome that is perceived as an advantage by one or more	outcomes	60	0.11%	0.17%	
			outcome	34	0.06%		
			benefits	23	0.04%		
			benefit	19	0.04%		
			impact	219	0.41%		
			impacts	19	0.04%		
		longer term goals - values at end of project	value	101	0.19%	0.64%	
			end	73	0.14%		
			goals	165	0.31%		
				952	1.79%		
Leadership	Context	Leadership as theme	leadership	83	0.16%	0.29%	0.80%
			leaders	30	0.06%		
			leading	20	0.04%		
			leads	15	0.03%		
				148	0.29%		
		Strategy	strategy	75	0.14%	0.18%	
			strategic	23	0.04%		
				98	0.18%		
		Leadership role	ceo	26	0.05%	0.12%	
			executive	37	0.07%		
				63	0.12%		
		Strategic planning competency	align	25	0.05%	0.21%	
			governance	25	0.05%		
			alignment	18	0.03%		
			direction	18	0.03%		
			vision	28	0.05%		
				114	0.21%		

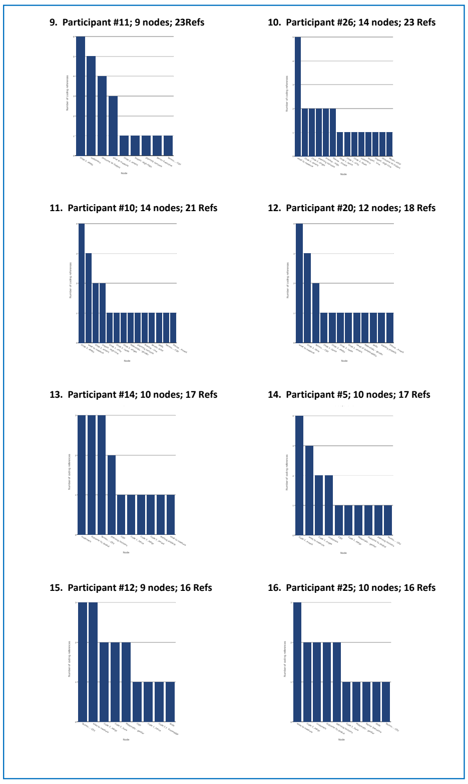
Sub-Category			Word	Count	f1 Weighted %	f2 %	f3 %
Knowledge	Context	Learning & Education	learning	30	0.06%	0.15%	0.26%
			training	22	0.04%		
			education	29	0.05%		
		Experience	maturity	30	0.06%	0.11%	
			experience	29	0.05%		
				140	0.26%		
Performance Management	Mechanism	Targets and measuring	target	31	0.06%	1.36%	1.90%
			targets	208	0.39%		
			objectives	26	0.05%		
			indicators	76	0.14%		
			measure	142	0.27%		
			measuring	72	0.14%		
			measuring	72	0.14%		
			measurement	54	0.10%		
			measured	17	0.03%		
			measures	21	0.04%		
				719	1.36%		
		Performance management - quuantitative	management	83	0.16%	0.43%	
			performance	54	0.10%		
			metrics	46	0.09%		
			objectives	26	0.05%		
			quantitative	18	0.03%		
		Qualitative contribution	contribution	40	0.08%	0.11%	
			qualitative	17	0.03%		
				284	0.38%		
Tools, Systems; Processess	Mechanism	Tools	tools	32	0.06%	0.06%	0.34%
		Process	processes	26	0.05%	0.23%	
			process	93	0.18%		
		Systems	system	26	0.05%	0.05%	
				177	0.34%		
Change Management	Context	Change Culture	change	129	0.24%	0.28%	0.78%
			culture	23	0.04%		
				152	0.28%		
		Behaviours	honest	22	0.04%	0.10%	
			collaborative	14	0.03%		
			collective	14	0.03%		
				50	0.10%		
		Innovative Commitment to change	opportunity	54	0.10%	0.34%	
			opportunities	20	0.04%		
			commitment	42	0.08%		
			innovation	32	0.06%		
			investment	32	0.06%		
				180	0.34%		
		Communications	communication	14	0.03%	0.06%	
			communications	14	0.03%		
				28	0.06%		
Project; Programme; Portfolio	Context	Project Level	project	278	0.52%	12.61%	13.01%
			projects	185	0.35%		
				6751	12.61%		
		Programme Level	program	65	0.12%	0.35%	
			program	65	0.12%		
			programme	31	0.06%		
			programs	27	0.05%		
				188	0.35%		
		Portfolio Level	portfolio	26	0.05%	0.05%	
Geography - levels	Context	Global	global	127	0.24%	0.44%	0.63%
			world	106	0.20%		
		National	national	62	0.12%	0.19%	
		Local	local	38	0.07%		
				333	0.63%		

Appendix 11 – participants' Data Charts of Frequency of Nodes and References

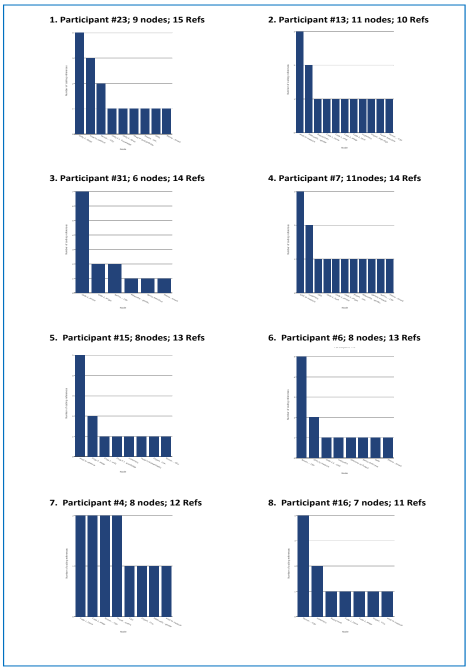
Participant Charts of Frequency of Nodes & Reference
(1-8 of highest frequency range)



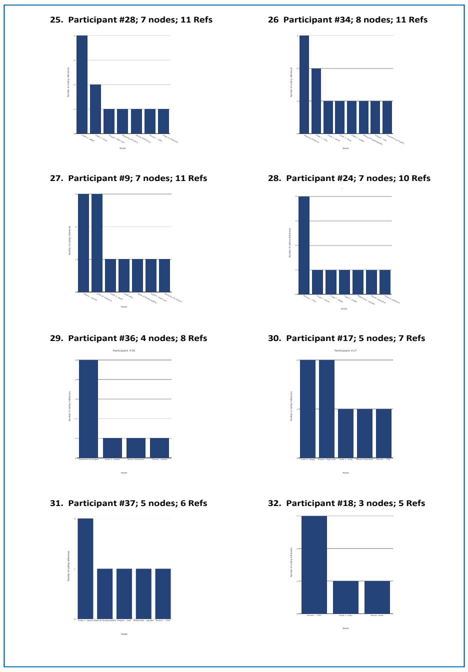
Participant Charts of Frequency of Nodes & Reference
(9-16 of highest frequency range)



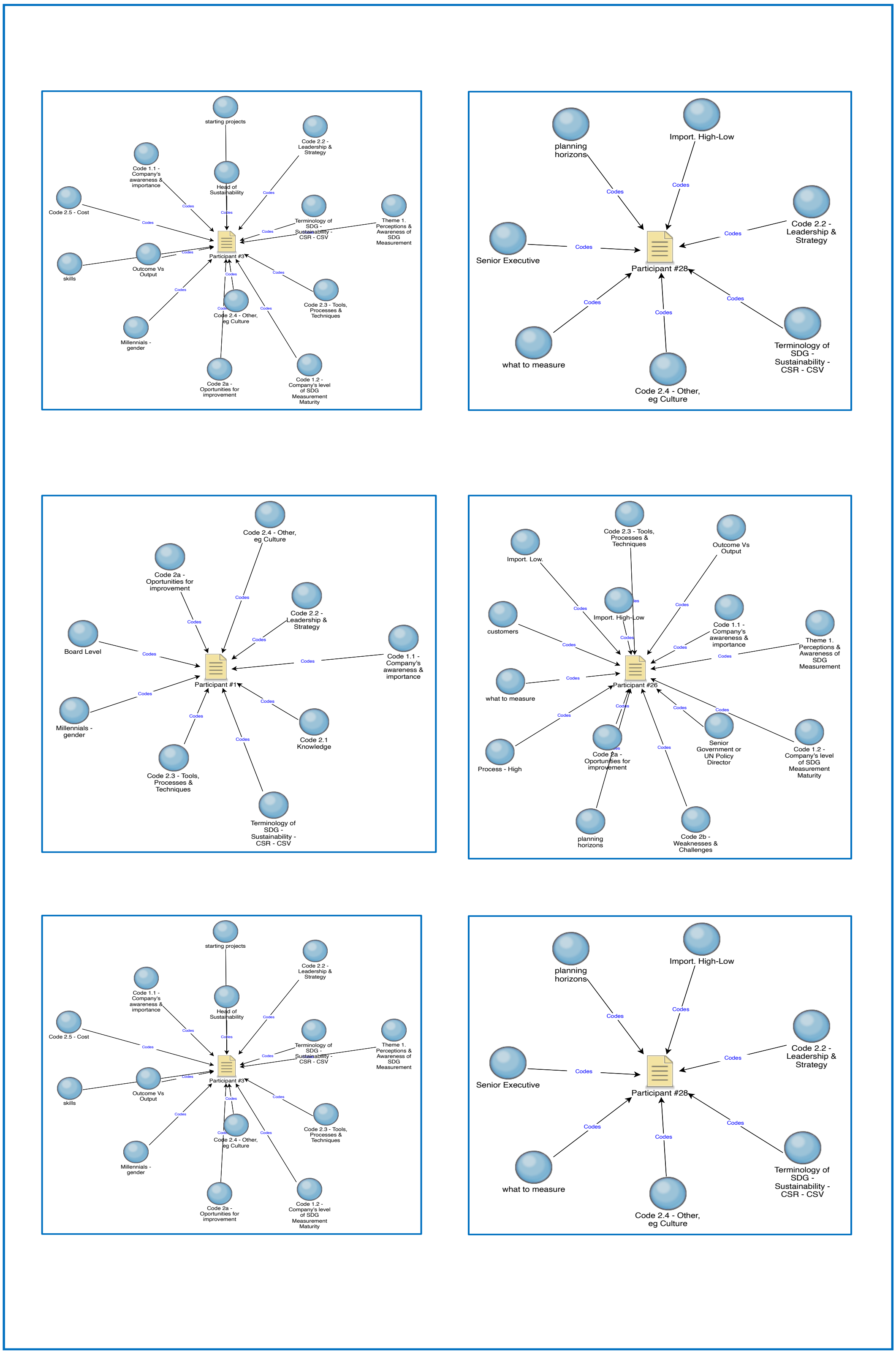
Participant Charts of Frequency of Nodes & Referenc
(17-24 of highest frequency range)



Participant Charts of Frequency of Nodes & Reference
(25-32 of highest frequency range)



Appendix 12 - Nodal Touch Point Charts of participants (6 examples)



Appendix 13 - Interview semi-structured approach – Outline of Questions

Draft Questions for 1-2-1 Interviews for PhD Research into 'Measuring Impact of Engineering Projects to achieve the Sustainable Development Goals'			
1	**Opening**	> Thanks for your time > Have you read and signed the consent form? > Can I confirm that we have the full 45 mins for the interview?	2 mins
2	**Role**	Your current role	3 mins
3	**Personal commitment to SDGs**	Your personal commitment to SDG's	5 mins
4	**Company commitment to SDGs & level of maturity**	Your company's current approach to measuring SDG impact at project level: > Do you have a SDG lead? Is that the same role/person as your CSR lead? > Which category are you in, as regards measuring projects' SDG impact?: > Aware and doing it > Aware and not doing it > Unaware and not doing it > If you are aware and dong it, what maturity level are you at (using P3M3 level descriptors)? > Level 1 - Awareness of Process - informal, no standard process > Level 2 - Repeatable Process - limited consistency and coordination > Level 3 - Defined Process - centrally controlled processes which can be tailored > Level 4 - Managed Process - management metrics, capability assessment & quality management > Level 5 - Optimized Process - continuous process improvement & optimised processes	5 mins
5	**Future SDG Impact Development**	SWOT discussion on the challenges and opportunities of doing this better.	25 mins
5.1		**Strength**: of current SDG impact measurement on engineering projects?	
5.2		**Weakness**: of current SDG impact measurement on engineering projects?	
5.3		**Opportunities** for future SDG impact measurement on engineering projects?	
5.4		**Threats** of future SDG impact measurement on engineering projects?	
6	**GEC engagement**	Are you planning to attend the Global Engineering Congress from 22-26 Oct 18?	2 mins
7	**Closing**	> Any final points that we haven't covered that you feel are important to this subject area? > Thanks for your time and I will ensure that the copy of the ICE report and the academic papers are passed to you personally	3 mins

Appendix 14 - Participant Information Form

ice

Participation Information Form

Project title:

'Measuring Impact of Engineering Projects to achieve the Sustainable Development Goals'

Lead researcher:

Paul Mansell

Contact Details:

Email: paulrmansell@gmail.com Mobile number: 07795302258

Dear participant,

Please read through the following information sheet before deciding to be a participant in this study. The investigation is completely voluntary giving you the option to choose whether or not you wish to participate.

Aims of research:

The purpose of this study is to provide a more in-depth understanding of UN Sustainable Development Goals, specifically SDG 13 on climate change, and why there is a gap between the high-level SDG political rhetoric and what is actually happening on engineering projects to measure their SDG impact against the 2030 targets. The research will be closely aligned with the engineering community to develop tools and approaches that can enable the SDG impacts to be measured effectively and thus to ensure maximum SDG value from the critical infrastructure's investment beyond the traditional success definition of time, cost and quality.

What you will be required to do as a participant of this study:

During the study you will be asked to engage in a semi structured interview with the PhD research investigator, Paul Mansell. The interview will last approximately 45 minutes. As a participant you will be questioned about: your current role; your personal commitment to SDG's; your company's current approach to measuring SDG impact at project level; and a discussion on the challenges and opportunities of doing this better.

Pre Interview all participants will receive a copy of the questions to become familiar with some of the themes that will be discussed during the interview.

1

What type of participants am I seeking?

Having conducted a survey jointly with the ICE with over 300 respondents, I am now seeking the opportunity to engage with CEOs and their SDG/CSR leads. Ideally this would enable two interviews with each organisation, since the views of the leadership will be critical to gauge the viability of responding to this issue effectively.

What are the risks of participating in this study?

All the information given in the interview will remain anonymous, unless specific quotes are to be published in which case the research lead and ICE would ensure that clearance for the quotes were formally obtained prior to inclusion in the publication.

What are the benefits to the participant involved in the study?

The results will provide insight into how the engineering firms can engage more effectively with SDG, specifically finding ways to measure SDG impact on their projects. There will be one 'glossy' report produced by the ICE in August, and one academic paper in September. Both will be inputs to the Global Engineering Congress from 22-26 October.

What will happen to the information collected?

All the information will be held securely and will only be accessible to the researcher. The ICE and University will hold the information for up to seven years, after this the data will be destroyed.

What's next?

If you have any questions regarding the study, please do not hesitate to contact me. If you would like to take part in this investigation you will need to fill out a 'Participation consent form' which will be provided by the research investigator.

Many thanks,

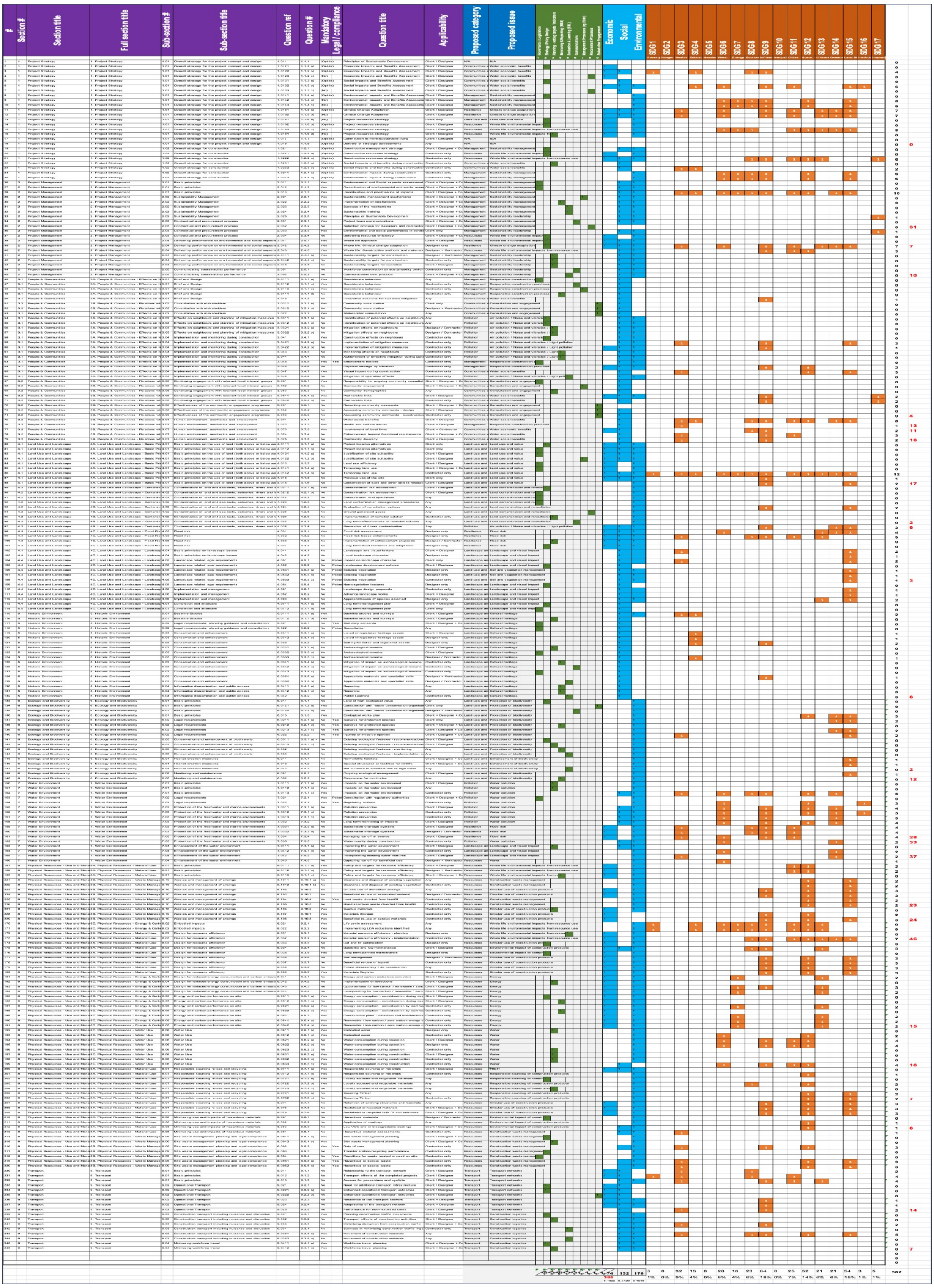
Paul Mansell – PhD Student sponsored by the Nathu Purri Institute

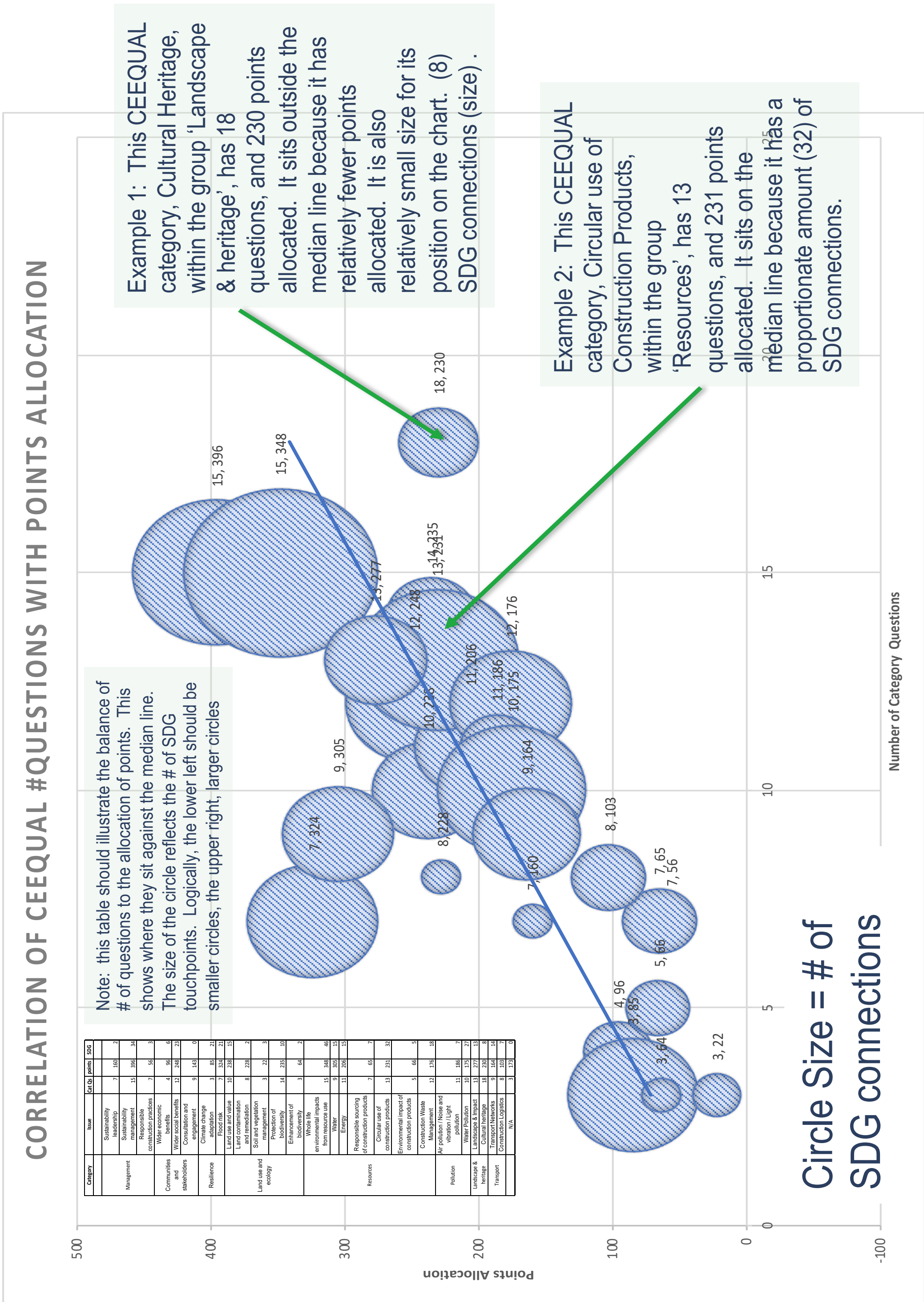
Email: paulrmansell@gmail.com Mobile number: 07795302258

Supervisor: Professor Rao Bhamidimarri, School of Engineering, Nathu Purri Institute; 07548 030346

Appendix 15 – Full Matrix of CEEQUAL Mapping to SDGs.

Full matrix analysis of CEEQUAL's Categories and 246 questions' relative focus on TBL and across the 17 SDGs. Each shaded square represents a linkage.




CORRELATION OF CEEQUAL #QUESTIONS WITH POINTS ALLOCATION
Example 1: This CEEQUAL category, Cultural Heritage, within the group 'Landscape & heritage', has 18 questions, and 230 points allocated. It sits outside the median line because it has relatively fewer points allocated. It is also relatively small size for its position on the chart. (8) SDG connections (size) .
Example 2: This CEEQUAL category, Circular use of Construction Products, within the group 'Resources', has 13 questions, and 231 points allocated. It sits on the median line because it has a proportionate amount (32) of SDG connections.
Note: this table should illustrate the balance of # of questions to the allocation of points. This shows where they sit against the median line. The size of the circle reflects the # of SDG touchpoints. Logically, the lower left should be smaller circles, the upper right, larger circles
Circle Size = # of SDG connections
Points Allocation
Number of Category Questions
18, 230
15, 396
15, 348
14, 235
13, 231
13, 277
12, 248
12, 176
11, 206
11, 186
10, 175
10, 226
9, 305
9, 164
8, 228
8, 103
7, 324
7, 160
7, 65
7, 56
5, 66
4, 96
3, 85
3, 64
3, 22
500
400
300
200
100
0
-100
0
5
10
15
20
25

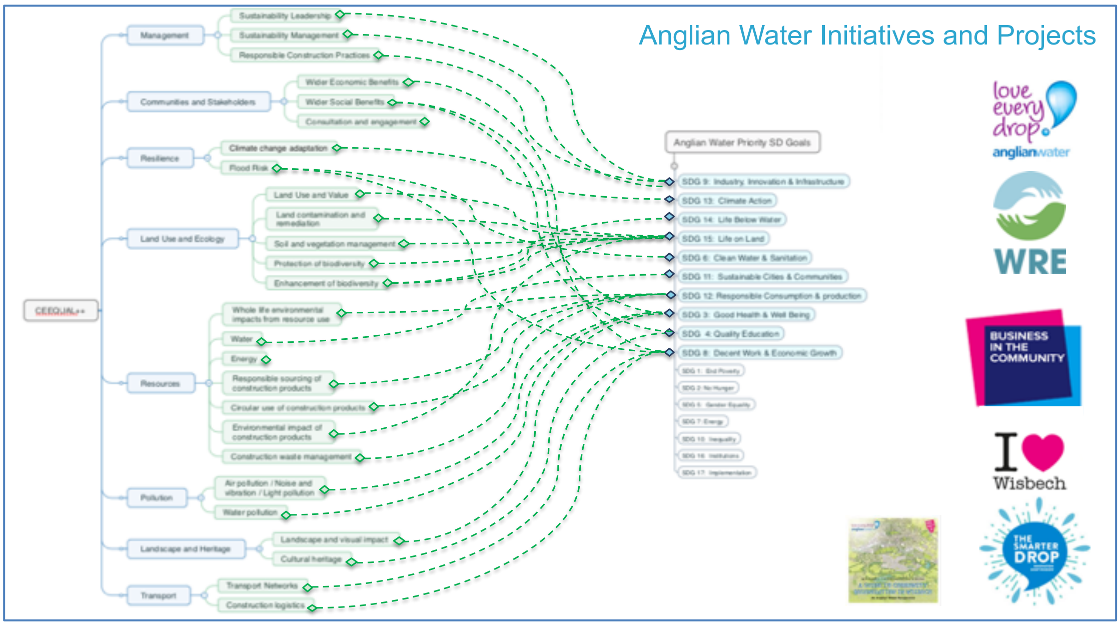
Appendix 16 – Anglian Water's mapping of SDG targets to the 27 Projects.

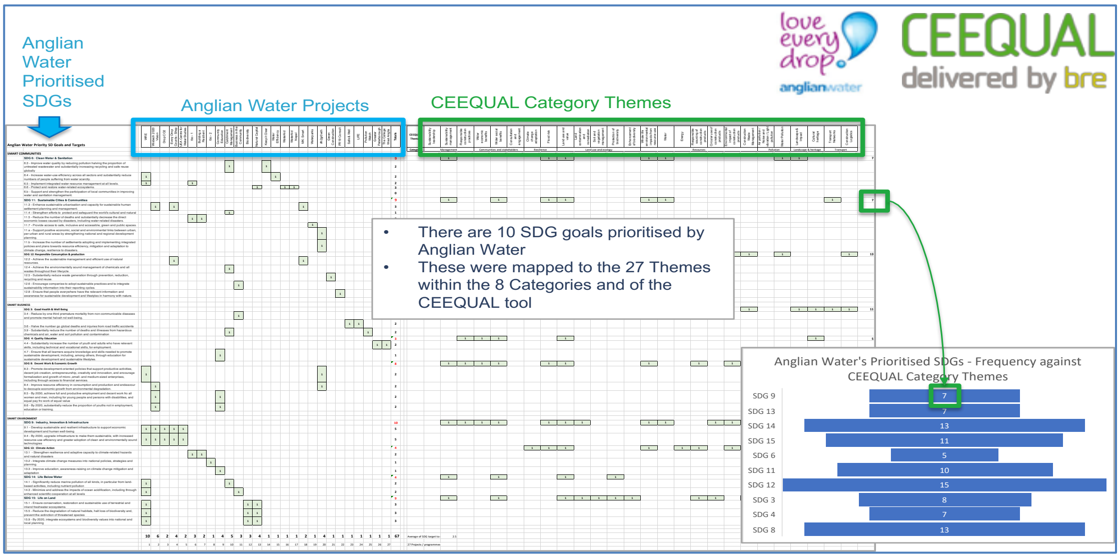
Anglian Water Priority SD Goals and Targets	WRE	Wisbech 2020 Vision	Drop CO2	Every Drop Counts - Shop	UEA Centre for Water Studies	tbc - 1	Building a Resilient Future	tbc - 2	Community Education	Catchment Management	Business in the Community	Biodiversity	Natural Capital	Keep it Clear	Water Efficiency	WaterAid	WaterAid Nepal	MK: Smart	Waterparks	#h2gr0wth	Green Construction	PR19 Consult	Safe & Well	LIFE	Pollution Watch	Greater Peterborough	The College West Anglia	Totals
SMART COMMUNITIES																												
SDG 6: Clean Water & Sanitation																												9
6.3 - Improve water quality by reducing pollution halving the proportion of untreated wastewater and substantially increasing recycling and safe reuse globally										1				1														2
6.4 - Increase water-use efficiency across all sectors and substantially reduce numbers of people suffering from water scarcity.	1														1													2
6.5 - Implement integrated water resource management at all levels.	1					1																						2
6.6 - Protect and restore water-related ecosystems.													1			1	1											3
6.b - Support and strengthen the participation of local communities in improving water and sanitation management.																												0
SDG 11: Sustainable Cities & Communities																												9
11.3 - Enhance sustainable urbanisation and capacity for sustainable human settlement planning and management.		1		1														1										3
11.4 - Strengthen efforts to protect and safeguard the world's										1																		1
11.5 - Reduce the number of deaths and substantially decrease the direct economic losses caused by disasters,						1	1																					2
11.7 - Provide access to safe, inclusive and accessible, green																			1									1
11.a - Support positive economic, social and environmental links between urban, per-urban and rural areas by strengthening national and regional development planning.																				1								1
11.b - Increase the number of settlements adopting and implementing integrated policies and plans towards resource efficiency, mitigation and adaptation to climate change, resilience to disasters.																				1								1
SDG 12: Responsible Consumption & production																												6
12.2 - Achieve the sustainable management and efficient use of natural resources.				1														1										2
12.4 - Achieve the environmentally sound management of chemicals and all wastes throughout their lifecycle.										1																		1
12.5 - Substantially reduce waste generation through prevention, reduction, recycling and reuse.																					1							1
12.6 - Encourage companies to adopt sustainable practices and to integrate sustainability information into their reporting cycles.											1																	1
12.8 - Ensure that people everywhere have the relevant information and awareness for sustainable development and lifestyles in harmony with nature.																						1						1
SMART BUSINESS																												
SDG 3: Good Health & Well Being																												5
3.4 - Reduce by one third premature mortality from non-communicable diseases and promote mental halvah nd well-being.											1																	1
3.6 - Halve the number go global deaths and injuries from road traffic accidents																							1	1				2
3.9 - Substantially reduce the number of deaths and illnesses from hazardous chemicals and air, water and soil pollution and contamination										1															1			2
SDG 4: Quality Education																												3
4.4 - Substantially increase the number of youth and adults who have relevant skills, including technical and vocational skills, for employment.																										1	1	2
4.7 - Ensure that all learners acquire knowledge and skills needed to promote sustainable development, including, among others, through education for sustainable development and sustainable lifestyles.									1																			1
SDG 8: Decent Work & Economic Growth																												8
8.3 - Promote development-oriented policies that support productive activities, decent job creation, entrepreneurship, creativity and innovation, and encourage formalization and growth of micro-,small- and medium-sized enterprises, including through access to financial services.	1																			1								2
8.4 - Improve resource efficiency in consumption and production and endeavour to decouple economic growth from environmental degradation.		1																		1								2
8.5 - By 2030, achieve full and productive employment and decent work fro all women and men, including for young people and persons with disabilities, and equal pay fro work of equal value		1							1																			2
8.6 - By 2020, substantially reduce the proportion of youths not in employment, education or training.		1							1																			2

SMART ENVIRONMENT																												
SDG 9: Industry, Innovation & Infrastructure																												10
9.1 - Develop sustainable and resilient infrastructure to support economic development and human well-being	1	1	1	1	1																							5
9.4 - By 2030, upgrade infrastructure to make them sustainable, with increased resource-use efficiency and greater adoption of clean and environmentally sound technologies	1	1	1	1	1																							5
SDG 13: Climate Action																												4
13.1 - Strengthen resilience and adaptive capacity to climate-related hazards and natural disasters						1	1																					2
13.2 - Integrate climate change measures into national policies, strategies and planning.								1																				1
13.3 - Improve education, awareness-raising on climate change mitigation and adaptation									1																			1
SDG 14: Life Below Water																												4
14.1 - Significantly reduce marine pollution of all kinds, in particular from land-based activities, including nutrient pollution	1									1																		2
14.3 - Minimize and address the impacts of ocean acidification, including through enhanced scientific cooperation at all levels	1										1																	2
SDG 15: Life on Land																												9
15.1 - Ensure conservation, restoration and sustainable use of terrestrial and inland freshwater ecosystems.	1											1	1															3
15.5 - Reduce the degradation of natural habitats, halt loss of biodiversity and, prevent the extinction of threatened species	1											1	1															3
15.9 - By 2020, integrate ecosystems and biodiversity values into national and local planning	1											1	1															3
Average of SDG target to each project	10	6	2	4	2	3	2	1	4	5	3	3	4	1	1	1	1	2	1	4	1	1	1	1	1	1	1	67
27 Projects / programmes	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25	26	27	

Table 40: Anglian Water's mapping of SDG targets to the 27 Projects. The y-axis shows the 35 SDG targets selected at Anglian Water corporate level; the x-axis shows the 27 projects that they are allocated to by Anglian Water (AW).

The representation, shown in Table 40, of mapping Anglian Water's top 27 projects to their prioritised SDG targets shows that all projects had at least one target to measure success against, while one project had 10 targets to map success against. This mapping by Anglian Water highlights that only a few targets can realistically be measured at project level. It also suggests that, if the targets are measured across a portfolio of projects and programmes, then a composite SDG impact measurement could be made. This would provide useful insights to support investment appraisals that seek to better understand the strategic impacts of investments and their broader TBL's return on investment.





Appendix 16 – Anglian Water's mapping of SDG targets to the 27 Projects.

Appendix 17 – MISI Impact Statement from Government & Industry Partners

(Note: all the letters of support for MISI Impact have been formally sanctioned to be included in this thesis by the named individuals)

The MISI research outputs, designed and led by the doctoral researcher, have been taken forward by the government and industry partners, specifically the Environment Agency and Thames Tideway Project, working together to establish this new approach for measuring sustainability on infrastructure projects.

Impact at the Environment Agency. "Following on from the MISI Project, we will be able to embed the knowledge that was generated by the project to support the measurement of SDG performance across our new portfolio of Environment Agency projects to be launched on 1st April 2021, which will total £5.2billion and include around 15 major projects in excess of £50million. Moreover, the approach to SDG measurement developed in the MISI Project will directly help us deliver our new sustainability strategy (known as eMissiion2030) and this will have huge positive impact that directly contributes to: saving lives; protecting hospitals, schools and homes; and regulating environmental impacts; as well as providing value for money for the UK Government". Quote from the Deputy Director Allocation & National Programme Management, Environment Agency (See Appendix 18).

Impact at Tideway. The Thames Tideway Tunnel is one of the largest infrastructure projects being delivered in Europe with a budget of £4.9billion and with a primary purpose to reduce sewage overflows into the River Thames.

"The development of the processes, tools and insights from the MISI Project can directly be utilised across the Thames Tideway Tunnel to ensure we are adequately capturing SDG performance for this major infrastructure project".

"Tideway aligned the financing of the project to the company's sustainability commitments and issued £1.8 billion of sustainable debt so far. We developed a sustainable finance communication strategy to attract and retain investors and aligned the reporting with the relevant SDGs. To this end, the work we have done on the MISI Project helped enhance the way we communicate our work on the SDGs, both in our Annual Report and in our Sustainable Finance Report. This has been well received by various stakeholders". Quotes from the Group Treasurer of Tideway (See Appendix 19).

Impact with wider stakeholders. Other quotes about the research impact were:

"The outputs of the MISI Project, which builds on earlier research from LSBU, has made it clear to us that significant progress on measuring the SDG performance of infrastructure projects has been secured". Quote from the Executive Director, **UN Global Compact Network** UK (See Appendix 20).

"At the IPA we recognised at an early stage that the MISI Project had significant potential to help all projects with their contribution to the SDGs". Quote from the Director Project Delivery, **Infrastructure and Projects Authority** (See Appendix 21).

"The outputs of the MISI Project, which builds on earlier research from LSBU, has made it clear to us and our community of ca. 100,000 members across 150 plus countries that major progress on measuring the SDG performance of infrastructure projects has been made in a short timeframe". Quote from the Director General and Secretary, **Institution of Civil Engineers** (See Appendix 22).

The impact of the SDG focused research on infrastructure projects at LSBU has also been recognised in an article in "*The Source - Magazine of the International Water Association*" (Hayward, 2019) and more recently in a publication by BRE on the BREEAM scheme, which is a key sustainability assessment tool used in the construction and built environment sector (**Building Research Establishment**, 2020) (See Appendix 23).

Appendix 18 – MISI Impact Statement of this research from the Environment Agency.

Letter of support from the Deputy Director Allocation & National Programme Management, Environment Agency, 24th September 2020 (available upon request):

Environment Agency

Professor.Simon Philbin
Director of the Nathu Puri Institute for Engineering and Enterprise
School of Engineering
London South Bank University
103 Borough Road
London SE1 0AA

24 September 2020

Dear Professor Philbin

Impact of the MISI (Measurement of Infrastructure SDG Impact) Project

This letter is to identify the impact and value secured by the Environment Agency from the Measurement of Infrastructure SDG Impact (MISI) Project that was undertaken in the early part of 2020. The project was carried out by the Nathu Puri Institute for Engineering and Enterprise at London South Bank University (LSBU) and included the contributions of several organisations including the Environment Agency.

At the Environment Agency we recognised at an early stage that the MISI Project had significant potential to help the Agency measure its performance against the United Nations (UN) Sustainable Development Goals (SDGs). In regard to the outputs of the MISI Project, which builds on earlier research from LSBU, it is clear to me that great progress on measuring the SDG performance of infrastructure projects has been made in a short timeframe. The MISI Project included a case study of the Boston Barrier project, which is a flood protection scheme costing over £100million. The project will provide an improved level of flood protection to over 20,000 homes and businesses, thereby protecting against tidal surges, such as the event in 2013 that flooded over 820 homes and businesses. Therefore, we are convinced of the need to promote the MISI Project outcomes of identifying local investments priorities through the SDG lens.

As a consequence of the MISI Project that builds on the previous research from LSBU, I am particularly pleased to see the linking of the portfolio level SDG measurement activity with the project level local issues and this represents a completely new way of measuring sustainability across major infrastructure projects. The objective to design the portfolio level approach with local project teams having 'freedom within a framework' is excellent. The development of processes, tools and knowledge by the MISI Project to support the Environment Agency embed the SDG measurement into our existing work is hugely helpful and represents a major step-change for us. The MISI Project has produced a number of practical tools that the Environment Agency is evaluating to deliver SDG measurement across our portfolio of projects worth £5.2billion, which in turn, provides real value to us and our stakeholders across the United Kingdom.

Following on from the MISI Project, we will be able to embed the knowledge that was generated by the project to support the measurement of SDG performance across our new portfolio of Environment Agency projects to be launched on 1st April 2021, which will total £5.2billion and include around 15 major projects in excess of £50million. Moreover, the approach to SDG measurement developed in the MISI Project will directly help us deliver our new sustainability strategy (known as eMissiion2030) and this will have huge positive impact that directly contributes to: saving lives; protecting hospitals, schools and homes; and regulating environmental impacts; as well as providing value for money for the UK Government.

Environment Agency, Rivers House, East Quay, Bridgwater, TA6 4YS

The progress of the MISI Project and underpinning research by LSBU and partners has been rapid and has delivered real value for us and will likely be greatly valued by the wider sector. For example, we have been working closely with the LSBU lead researcher, Paul Mansell, and the UK Cabinet Office and HM Treasury's Infrastructure Project Authority to develop our learning in a way that we can roll-out the research more widely across UK's full infrastructure portfolio. It is excellent to see the team's hard work and dedication to translate the findings from the doctoral research at LSBU into knowledge and benefits arising from the MISI Project.

Yours sincerely

JMRusson

John Russon
Deputy Director Allocation & National Programme Management
Mobile: 07741 007218
john.russon@environment-agency.gov.uk

Appendix 19 – MISI Impact Statement of this research from the Thames tideway project.

Letter of support from the Group Treasurer of Tideway, 27th October 2020:

Tideway

Prof. Simon Philbin
Director of the Nathu Puri Institute for Engineering and Enterprise
School of Engineering
London South Bank University
103 Borough Road
London SE1 0AA

27 October 2020

Dear Prof. Philbin,

Capturing Impact of the MISI (Measurement of Infrastructure SDG Impact) Project

I realise that it is important to capture how academic research is having a direct and quantifiable positive impact in practice and especially for major infrastructure projects. As a result, I wanted to share some of the areas where I think we can leverage the research work from the MISI (Measurement of Infrastructure SDG Impact) Project that was carried out by the Nathu Puri Institute for Engineering and Enterprise at London South Bank University (LSBU) and partners. This will include our legacy work that seeks to share best practice across our sector, but particularly with large mega-projects in the UK and abroad. It is also important to harness the resulting knowledge and keep improving the way we deliver improved performance.

As you know the Thames Tideway Tunnel will be a 25 km tunnel running under the tidal section of the River Thames and through central London. The tunnel has been designed to capture, store and convey almost all the raw sewage and rainwater that currently overflows into the river. The Thames Tideway Tunnel will intercept over 90% of the millions of tonnes of sewage overflowing into the tidal Thames in a typical year from the capital's overloaded Victorian sewer system. It is being delivered by Tideway, an independent regulated company. The Thames Tideway Tunnel is one of the largest infrastructure projects currently being delivered in Europe and the project has a budget of ca. £4.9billion.

A sustainable legacy is what will be left behind after the construction of the tunnel. The primary purpose of the project is to reduce sewage overflows into the River Thames, delivering the core benefit of improved water quality and enhanced biodiversity. However, the scale of the project, and its place at the heart of one of the world's greatest cities, mean that it presents a historic legacy opportunity. As well as building the tunnel, Tideway aims to deliver a wider legacy for London to boost the river economy, increase jobs, improve safety standards and drive down carbon emissions. Our commitments have evolved into 54 metrics within our Legacy Plan which demonstrate how the project is delivering the objectives. For example, such legacy commitments include creating more than 4,000 direct sustainable jobs; using river transport to remove the majority (90%) of material excavated to create the main tunnel; and working with charity partners to employ one ex-offender per 100 workers on the project. We envisage such legacy commitments to have enduring benefits across London for many years to come.

Tel. 020 3744 4010
www.tideway.london

Bazalgette Tunnel Limited (trading as Tideway), Cottons Centre, Cottons Lane, London SE1 2QG
Registered in England and Wales No. 9553573. Registered office: Cottons Centre, Cottons Lane, London SE1 2QG

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Tideway

We have aligned our commitments to the UN Sustainable Development Goals (SDGs), identifying the main SDGs to which Tideway makes a direct contribution to. Tideway will make a long term direct contribution to SDG 6 Clean Water and SDG 11 Sustainable Cities. During construction, Tideway is making a significant contribution to eight other SDGs – some of these will have a lasting impact and/or will be handed over to other organisations.

It is evident to me that major progress has been made by the MISI Project that builds on the earlier research conducted by LSBU. As Tideway's project was over 50% complete at the time of engaging with the MISI Project, the analysis undertaken by Tideway's Sustainability and Treasury teams focused on mapping Tideway's experience to MISI's methodology and focused on matters that could be taken forward by Tideway. The development of the processes, tools and insights from the MISI Project can directly be utilised across the Thames Tideway Tunnel to ensure we are adequately capturing SDG performance for this major infrastructure project. Further to developing the Impact Value Change analysis for Tideway, we extended the mapping of our legacy commitments to the SDGs at target level and developed further our SDG narrative.

Tideway aligned the financing of the project to the company's sustainability commitments and issued £1.8 billion of sustainable debt so far. We developed a sustainable finance communication strategy to attract and retain investors and aligned the reporting with the relevant SDGs. To this end, the work we have done on the MISI Project helped enhance the way we communicate our work on the SDGs, both in our Annual Report and in our Sustainable Finance Report. This has been well received by various stakeholders.

Following on from the MISI Project, we have been able to embed the learning and knowledge from the project and original research from LSBU in order to improve our understanding of how we can effectively measure SDG performance across the Tideway project. As a result, we have continued discussions with the Environment Agency and the Infrastructure and Projects Authority, sharing our experience and legacy work. The MISI Project and the underpinning research from LSBU represents a leap forward in how sustainability can be measured across infrastructure mega projects such as the Thames Tideway Tunnel.

Finally, I would like to pass on our thanks for the diligence and dedication by Paul Mansell for his doctoral research studies at LSBU and for delivering the MISI Project earlier in 2020.

Yours sincerely

Ines Faden da Silva

Group Treasurer

Bazalgette Tunnel Ltd, trading as Tideway

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Appendix 20 – MISI Impact Statement of this research from the UN Global Compact Network UK.

Letter of support from the Executive Director, UN Global Compact Network UK, 2nd September 2020:

Global Compact
Network UK

Prof. Simon Philbin
Director
Nathu Puri Institute for Engineering and Enterprise
London South Bank University
103 Borough Road
London SE1 0AA

2 September 2020

Re. Feedback on the Measurement of Infrastructure SDG Impact Project

Dear Prof. Philbin

This letter is to provide feedback on the Measurement of Infrastructure SDG Impact (MISI) Project, which has been delivered by London South Bank University (LSBU) and various partners.

The UN Global Compact Network UK has been involved with the MISI Project since December 2019. We have been jointly investigating how infrastructure projects impact the United Nations (UN) Sustainable Development Goals (SDGs). The collaboration involving LSBU and the Environment Agency, Thames Tideway Project, Institution of Civil Engineers (ICE), the UK Government's IPA, and University College London (UCL) has ensured that emerging academic research is shared to support practitioners' response to the ubiquitous challenge of delivering the SDG 2030 targets.

The outputs of the MISI Project, which builds on earlier research from LSBU, has made it clear to us that significant progress on measuring the SDG performance of infrastructure projects has been secured. We believe this to be a very important contribution to achieving the SDGs as well as supporting corporate sustainability more generally. My team and I engage regularly with the UK business community and have on several occasions been asked about measuring SDG impact at project level. The UN Global Compact Network UK recognises the potential of the MISI Project to change the way we deliver major infrastructure projects across the UK and internationally in order to adequately capture performance against the UN SDGs.

We look forward to hearing more about this research in the future.

Yours sincerely

Steve Kenzie
Executive Director
UN Global Compact Network UK

UN Global Compact Network UK
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153-157 Goswell Road, London, EC1V 7HD

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Registered Office: Cooper House, Lower Charlton Estate, Shepton Mallett, Somerset, BA4 5QE

Appendix 21 – MISI Impact Statement of this research from the Infrastructure and Projects Authority, UK Government.

Letter of support from the Director Project Delivery, Infrastructure and Projects Authority, UK Government, 15th October 2020:

Infrastructure
and Projects
Authority

Prof. Simon Philbin
Director
Nathu Puri Institute for Engineering and Enterprise
London South Bank University
103 Borough Road
London SE1 0AA

Dear Prof. Philbin

Re. Feedback on the Measurement of Infrastructure SDG Impact Project

The Infrastructure and Projects Authority (IPA) in the Cabinet Office has been involved with the LSBU's MISI (Measurement of Infrastructure SDG Impact) Project since its inception in December 2019. We were jointly investigating how government projects impact the United Nations (UN) Sustainable Development Goals (SDGs). The collaboration with the Environment Agency, the Thames Tideway Project, Institution of Civil Engineers, UCL and the UN Global Compact have all ensured that emerging academic research has been shared to support practitioners in responding to the challenge of the SDG 2030 targets.

The UK Government is committed to the Net Zero target and the SDGs provide an additional lens to structure our investment decisions to ensure maximum value from our infrastructure. At the IPA we recognised at an early stage that the MISI Project had significant potential to help all projects with their contribution to the SDGs. We are continuing to work with partners, such as the Environment Agency, to see what this could mean for the wider UK portfolio of investments. The outputs of the MISI Project, which builds on earlier research from LSBU, has made it clear to us that great progress on measuring the SDG performance of infrastructure projects has been made in a short timeframe.

Measuring our collective impact is particularly important at this moment as the government aims to drive a revolution in how we deliver major projects. Over the coming months, for example, we will be working to 'reset' the Government's Major Projects Portfolio (GMPP) so that it properly reflects our country's priorities and as reported in the IPA's Annual Report.

Yours sincerely,

Alison Baptiste
Director Project Delivery, IPA

Reporting to HM Treasury
and Cabinet Office

Appendix 22 – MISI Impact Statement of this research from the Institution of Civil Engineers.

Letter of support from the Director General and Secretary, Institution of Civil Engineers, 1st September 2020:

From the Director General and Secretary
NG Baveystock DL MA CEng FICE FInstRE CCMI

1 September 2020

Prof. Simon P. Philbin
Director
Nathu Puri Institute for Engineering and Enterprise
London South Bank University
103 Borough Road
London SE1 0AA

Institution of Civil Engineers
One Great George Street
Westminster
London SW1P 3AA
United Kingdom
T: +44 (0)20 7665 2004
E: nick.baveystock@ice.org.uk

Dear Prof. Philbin

MISI (Measurement of Infrastructure SDG Impact) Project

This letter is to provide feedback on the MISI (Measurement of Infrastructure SDG Impact) Project, which has been undertaken by London South Bank University (LSBU) and collaborative partners. As you know the Institution of Civil Engineers (ICE) has been involved with this work since the inception of the previous research studies in December 2017.

Not only did the ICE contribute R&D funding to this work, but we also used the opportunity to engage our membership through surveys and interviews, to explore this important area of research. You will recall the first empirical study was a key paper that informed our Global Engineering Congress (GEC) in October 2018, which was attended by over 3,500 infrastructure industry senior leaders over 7 days. We understand that since then there have been several more publications arising from the research, including the recent article on assessing the impact of infrastructure projects on global sustainable development goals that was published in the *Proceedings of the Institution of Civil Engineers – Engineering Sustainability*.

More recently the research team has been investigating practical ways of how projects can realistically and sensibly impact the United Nations (UN) Sustainable Development Goals (SDGs) at a local level. The collaboration with the Environment Agency, the Thames Tideway Project, UN Global Compact, the UK Government's IPA and UCL have all ensured that emerging academic research has been shared to support practitioners respond to the ubiquitous challenge of delivering the SDG 2030 targets.

The outputs of the MISI Project, which builds on earlier research from LSBU, has made it clear to us and our community of *ca.* 100,000 members across 150 plus countries that major progress on measuring the SDG performance of infrastructure projects has been made in a short timeframe.

I look forward to the ICE continuing to be engaged in the programme.

With best wishes

NG Baveystock

Appendix 23 – MISI Impact Statement of this research from the Building Research Establishment (BRE).

Letter of support from the Strategic Relationship Lead BRE Global and Director CEEQUAL, Building Research Establishment, 19th October 2020:

BRE Global
Bucknalls Lane
Watford, Herts
WD25 9XX

T: +44 (0)333 321 8811
E: BREGlobalEnquiries@bregroup.com
W: www.bregroup.com/breglobal

Prof. Simon P. Philbin
Director
Nathu Puri Institute for Engineering and Enterprise
London South Bank University
103 Borough Road
London SE1 0AA

Date: 19 October 2020
Our Ref.:
Your Ref.:

Dear Prof. Philbin,

Impact of the MISI (Measurement of Infrastructure SDG Impact) Project

This letter is to provide feedback on the MISI (Measurement of Infrastructure SDG Impact) Project, which has been undertaken by London South Bank University (LSBU) and collaborative partners, including the BRE, Institution of Civil Engineers, University College London, and various industry partners including the Environment Agency..The BRE Trust provided some funding to this project to enable LSBU's PhD student, Paul Mansell, to extend his research to cover a specific review of the SDGs against our CEEQUAL sustainability rating and certification scheme for infrastructure.

This review was important because we have been increasingly aware, as the construction sector is being required to measure their performance with the SDG goals, of the need to ensure our family of sustainability rating schemes (CEEQUAL, BREEAM and Home Quality Mark) are aligned to the framework of SDG goals and indicators.

In order to adopt the goals in the construction industry, direct and indirect solutions must be considered. Understanding a layered approach to tackling the SDGs is key to understanding the role each individual business can carry out in order to play their part. As the SDGs are country level goals, direct correlation to the specific targets and indicators can be difficult. Understanding the indirect relationship, a commercial business has with the goals can be just as important in facilitating the national or global achievement of the SDGs.

Paul, along with researchers at BRE, University College London and London South Bank University, was able to identify a link between best-practice sustainability-reporting frameworks at the project level and those at the organisational level (such as GRI). This enabled the alignment of such frameworks to the SDG's allowing SDG impact targets to be embedded into the design and construction of an infrastructure project. The work carried out has been published by the Institute of Civil Engineers: 'Assessing the impact of infrastructure projects on global sustainable development goals.' Mansell, P., et. al. 2019, November. In Proceedings of the Institution of Civil Engineers-Engineering Sustainability (Vol. 173, No. 4, pp. 196-212). Thomas Telford Ltd.

Date: 19 October 2020
BRE Global Ref.:

In addition since the completion of this research, BRE have adopted the approach Paul used on CEEQUAL to analyse the whole family of BREEAM sustainability schemes and have now published a mapping document, to help industry available here https://www.breeam.com/sdg/

Yours sincerely

Ian Nicholson

Ian Nicholson
Strategic Relationship Lead - Infrastructure
For and on behalf of BRE Global Limited
Telephone: +44 (0)1923 664409
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Appendix 24 – Publications in Advance of Thesis

The LSBU Research Degree Code of Practice (2018), states the thesis should contain: abstract; statement of research objectives; references; info on any publications produced as part of the research, "either included as part of the thesis or placed in a pocket at the end of the thesis" (Research Degree Code of Practice, p.24). The list of 12 publications below includes the current list of publications (incl 1 in review process).

Journal Papers

[1]. Mansell, P., Philbin, S. P., Broyd, T., & Nicholson, I. (2020). Assessing the impact of infrastructure projects on global sustainable development goals. *Proceedings of the Institution of Civil Engineers–Engineering Sustainability*, *173*(4), 196-212, https://doi.org/10.1680/jensu.19.00044.

[2]. Mansell, P., Philbin, S. P., & Konstantinou, E. (2020). Redefining the Use of Sustainable Development Goals at the Organisation and Project Levels—A Survey of Engineers. *Administrative Sciences*, *10*(3), 55, https://doi.org/10.3390/admsci10030055.

[3]. Mansell, P., Philbin, S. P., & Konstantinou, E. (2020). Delivering UN Sustainable Development Goals' Impact on Infrastructure Projects: An Empirical Study of Senior Executives in the UK Construction Sector. *Sustainability*, *12*(19), 7998, https://doi.org/10.3390/su12197998.

[4]. Mansell, P., Philbin, S. P., & Broyd, T. (2020). Development of a New Business Model to Measure Organizational and Project-Level SDG Impact—Case Study of a Water Utility Company. *Sustainability*, *12*(16), 6413, https://doi.org/10.3390/su12166413

[5]. Mansell, P., Philbin, S.P. (2020). Measuring Sustainable Development Goal Targets on Infrastructure Projects. *Journal of Modern Project Management*: https://openresearch.lsbu.ac.uk/item/8q171

[6]. Mansell, PM, Philbin, SP, Broyd, T, Nicholson - 'Measuring Infrastructure Projects' Impact on UN SDG Global Goals: Development of an SDG Impact-Value Chain for the Infrastructure Sector based on the Triple Bottom Line', *International Journal of Sustainability Society (IJSSOC)*. Submission code: IJSSOC-291855. Paper Accepted.

Paper Under Review

[7]. Mansell, P.M., Philbin, S.P., Van Rooyen, D., Sabini, L. (2020c). 'A Systematic Literature Review of Infrastructure Projects - Assessment Through SDG Targets: Towards a Comprehensive Framework', *Engineering Project Organization Journal* invited for inclusion post conference; in review process.

Conference Papers (Double Blind Reviewed) – published in proceedings

[8]. Mansell, P. Quantitative Survey Analysis: What Engineers and CEOs Currently Think about Sustainability and the SDGs. (2018). ICE Global Engineering Conference (reviewed by ICE editorial publishing team and the GEC Council prior to acceptance) https://www.researchgate.net/publication/327602328_Engineers_perception_of_value_of_SDGs_and_the_current_ability_to_measure_projects'_SDG_impact

[9]. Mansell, P., Philbin, S.P., Plodowski, A. (2019) Why Project Management is Critical to Achieving the SDGs, and How This Can be Achieved. Project Management Conference 2019, Delft University. https://pmcongress2019.org/

[10]. Mansell, P., Philbin, S.P., Konstantinou, E. (2019) 'Call to Arms': Using the Creating Shared Value Business Governance Paradigm to Deliver Projects' Business-Society Impact Against the UN SDG 2030 Targets. Proceedings of the EURAM (European Academy of Management) 2019 Conference, Lisbon, Portugal. http://www.euram-online.org/annual-conference-2019.html

[11]. Mansell, P., Philbin, S.P., and Boyd, T. (2019). Infrastructure Projects' Impact on Sustainable Development. In the Proceedings of 7th IPMA Research Conference and the 14th International OTMC Conference. 4-7 September 2019. Zagreb, Croatia, pp 570-592.

[12]. Mansell, P.M., Philbin, S.P., Van Rooyen, D., Sabini, L. (2020c). 'A Systematic Literature Review of Infrastructure Projects - Assessment Through SDG Targets: Towards a Comprehensive Framework', Paper accepted and presented to EPOC (Engineering Project Organization Society) on 2 June 2020.