Chapter 1
Modeling the Sustainable Development Nexus as a Complicated-Coupled System: Cross-Impact Network Analysis

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ABSTRACT

This chapter discusses the universal concept of a system through the lens of system thinking and science and applies it to the concept of sustainable development. Because system science is inherently multi-disciplinary, examples and concepts are borrowed from many disciplines. Any system can be explained through multiple dimensions or components of which this chapter details 'structure' by modeling systems as static cross-impact networks; it frames sustainable development—referred to as anthropocentric systems—as an interconnected group of sectors, like an economy, using a nexus approach. As nations work toward implementing the complex and interconnected United Nation's Sustainable Development Goals (SDGs), this chapter offers methods to identify the type of interactions and quantify the strengths among them. This approach supports the process of priority setting and highlights areas in particular needed for policy coordination across different sectors.

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SYSTEMS SCIENCE: AN INTRODUCTION

Systems Thinking

Systems science is a meta-science in that it applies universally to all fields (Mobus & Kalton, 2015). As such, it is also a mindset and a perspective – a philosophy of sorts – that one holds. It is not just an approach, a tool, or a methodology; systems science is the science of thinking, and more specifically, how to strategize for problems. The application of systems science to thinking is systems thinking. Therefore, systems thinking is the application of a universal understanding and is directly based on scientific principles. Systems thinking provides a conceptually easy way to introduce systems science and more complex topics. Before the science of systems can be discussed, it seems only appropriate that thinking with systems be explored. Systems thinking is not particularly that difficult or involved, and even just being open-minded is a part of systems thinking.

Systems thinking is a mindset so that one's perception of the world accounts for its inherent complexity. It opposes reductionism and linear thinking – the outdated worldview dominating scientific reasoning over the last 500 years – which is no longer sufficient to solve contemporary complex, ill-defined, and messy problems, namely rapid population growth, conflict, environmental degradation, and climate change among others. From a letter published in the New York Times (1946), Albert Einstein wrote that "a new type of thinking is essential if [humanity] is to survive and move toward higher levels." The letter was meant to address the challenges of the newly invented atomic weapons, but the quote fits any complex issue today. Systems thinking is that new type of thinking that can provide the overall approach for genuinely understanding and effectively strategizing for complex global challenges. A detailed description of systems thinking is left up to the myriad of excellent publications (see Braun, 2002; Capra & Luisi, 2016; Meadows, 2008, among many others).

Because systems thinking is a metascience, it shows up in virtually all areas such as the following: logistics and supply chain management (Barorikar, 2020); sustainable development & education (Zelinka & Amadei, 2017); construction projects (Bajracharya, 2014); socioeconomic development (Baporikar, 2016); biology, ecology, and the environment (Capra & Luisi, 2016; Ford, 2010); information & communications technology (Elharakany, Moscardini, Khalifa, & Elghany, 2018); startups (Shanbhag & Pardede, 2019); and many more.

As defined by Richmond (1994), systems thinking "is the art and science of making reliable inferences about behavior by developing an increasingly deep understanding of underlying structure" (p. 6). Another definition proposed by Sterman (2006) considers systems thinking as a new mindset with both depth and breadth and "an iterative learning process in which we replace a reductionist, narrow, short-term, static view of the world with a holistic, broad, long-term, dynamic view, reinventing our policies and institutions accordingly" (p. 509). Systems thinking and systems tools such as cross-impact analysis (CIA) and network analysis (NA), which are considered in this chapter, enable decision-makers to explore the cross-impact and interconnections across the SDGs more rigorously and analytically than just using intuition.

A systems or integrated approach requires a certain level of awareness and decision-making maturity. System thinking is learned, and anyone can become a systems thinker by adjusting their perspectives and adopting new habits (Table 1), according to the Waters Foundation (Benson & Marlin, 2017). These habits can also be understood as thinking strategies (visual, listening and speaking, and kinesthetic) that a decision-maker might want to follow to address complex problems. In the following table, habits in