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# HOLISTIC APPROACH TO THE SUSTAINABILITY OF COMPLEX SYSTEMS: AN INTEGRATIVE LITERATURE REVIEW

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**Report**

2025

# Abstract

**Objective:** The paper seeks to clarify how complex systems are defined in different disciplines and examines how their sustainability is understood and addressed. It is motivated by the need to inform the development of the conceptual framework to assess sustainability of the old-age support systems within the project "Connecting Pensions, Health and Care".

**Methods:** An integrative literature review was conducted using a systematic approach to identify and select relevant records. Five databases were searched, including Proquest - International Bibliography of the Social Sciences (IBSS), SCOPUS, Web of Science, PubMed, and IEEE Xplore. Data were extracted to explore: (a) the definition of a complex system, (b) principles, features, or characteristics underlining a complex system, (c) approaches adopted to visualise complex systems, (d) the meaning of sustainability, and (e) achieving the sustainability of a complex system. Thematic synthesis was employed to identify latent themes from the extracted data.

**Results:** Eighty-two records were included in the review. 89% of the records employed theoretical, qualitative, or other methodologies, such as policy analysis. Further analysis revealed overarching themes, including the concept of "holism" in defining a complex system. Based on this definition, the properties and behaviours of the system emerge from the interactions among its components. Regarding sustainability, several themes emerged, including the notion that sustainability must be embedded within the system as an emergent property.

**Conclusions:** The findings of this review support the explicit recognition of uncertainty when defining a complex system. It is crucial to remain within this frame when describing the interactions within the system, the outcomes of those interactions, and the overall system properties resulting from any intervention. Within this framing, sustainability need not be a predefined goal but rather an emergent property arising from the quality of interactions among the system's components.


**Keywords**: Complex system; Integrative review; Sustainability.

# Acknowledgements

The Nuffield Foundation is an independent charitable trust with a mission to advance social well-being. It funds research that informs social policy, primarily in Education, Welfare, and Justice. It also funds student programmes that provide opportunities for young people to develop skills in quantitative and scientific methods. The Nuffield Foundation is the founder and co-funder of the Nuffield Council on Bioethics, the Ada Lovelace Institute and the Nuffield Family Justice Observatory. The Foundation has funded this project, but the views expressed are those of the authors and not necessarily the Foundation. Visit www.nuffieldfoundation.org

We are thankful to Professor Sarah Vickerstaff and Dr Lavinia Mitton for their constructive review of the paper.

# Introduction

Systems are generally composed of different components or subsystems. In a simple system, these subsystems exist but may or may not interact, and when interactions occur, they follow simple, linear, and well-defined rules (Gallopín et al., 2008). In a complicated system, subsystems interact with one another, yet the outcomes from such interaction remain predictable (Rosas, 2017). In a complex system, the subsystems interact in dynamic and often, in unpredictable ways (Zazueta and Bahramalian, 2021; Rouchitsas et al., 2025).

Understanding interactions among subsystems in a complex system, and the outcomes from these interactions, is a priority particularly when considering strategies for system sustainability (Berrio-Giraldo et al., 2021; Voulvoulis et al., 2022). This is because the sustainability of the complex system becomes even more difficult to achieve when one cannot accurately predict the outcomes from any new intervention that targets the system or any of the sub-systems.

One premise for this difficulty is that the concept of complexity is interpreted differently across disciplines. For example, some studies in the field of sustainability science emphasise the structure of the system, that is, a broad system composed of multiple subsystems or components (Phillis et al., 2010; Porter, 2008; Clark and Harley, 2020; De Angelis, 2022; Leslie et al., 2015; Mobus, 2017; Albertí and Fullana-i-Palmer, 2018; Talukder et al., 2020). Others in the field of ecology, engineering, public health and architecture focus on the behaviour of system components (Cumming, 2011; Godfrey, 2010 Yanine and Sauma, 2013; Filotas et al., 2014; Moore et al., 2021; Chang et al., 2025). Still others in the field of management science, urban studies, and environmental management define complex systems by emphasizing the very nature of complexity, uncertainty, and adaptive learning that distinguishes complex systems from other kinds of system (Arévalo and Espinosa, 2015; Moore et al., 2021; Scrieciu et al., 2022; Malmborg et al., 2022).

However, to understand a complex system, the focus should be on the interactions among its components (Smith et al., 2025). This is because it is based on these interactions that the form and shape of the system emerge (Porter, 2008; Gu and Frazer, 2009; Anderies and Janssen, 2013; Motloch and Truex, 2015; James et al., 2021). That is, the behaviour of the system originates from the interconnections and interactions between subcomponents, and such behaviours cannot be observed from the properties of the individual parts (Yanine and Sauma, 2013). Also, sustainability of the system would not be achieved by targeting interventions on one of the components of the system (Voulvoulis et al., 2022).

Becoming sustainable is an extra layer of difficulty in a complex system because it requires more than adjusting deeply interconnected components of the system (Weaver et al., 2026). Moreover, this difficulty is further amplified because of the ambiguity in the definition of sustainability and its measurement (Gudmundsdottir and Sigurjonsson, 2024). For example, consider the concept of resilience and sustainability, which have been used interchangeably across studies in complexity science. While some studies consider resilience as the outcome of a sustainable complex system (Zhang et al., 2014; Grafius et al., 2020), others view resilience as a process towards achieving sustainability (Gillespie-Marthaler et al., 2019). This challenge cuts across disciplines. The field of environmental science, crisis and disaster management, geotechnical engineering and rock mechanics, and related fields, conceptually view resilience as an expression of a complex system (Cavallo and Ireland, 2014; Wohl et al., 2014; Dianat et al., 2022; Ruggiero et al., 2024; Chang et al., 2025; Miller et al., 2025). For studies in the field of sustainability science, there is a clearer distinction between resilience and sustainability (Leach et al., 2018; Gillespie-Marthaler et al., 2019).

In this study, we opened up our review as much as possible to clarify how complex systems are defined across disciplines and how sustainability is understood and addressed. We conducted an integrative literature review of 82 peer-reviewed publications published since the year 2000. This review was conducted to inform the development of a framework that can be adopted to understand complex systems and how their sustainability can be achieved. One related implication of this review is evident in how policies are often made without recognising that seemingly unconnected systems are, in fact, subsystems of a broader complex system.

Consider the three old-age support systems in England, which is the focus of the Nuffield-funded strategic research project “Connecting Pensions, Health and Care”. While the pension, healthcare, and long-term care systems can be considered separate systems that aim to address different dimensions of living well in old age, they are nevertheless interconnected. Any policy change or intervention that targets one of these systems (for example, the pension system) could have effects both on the targeted system itself and on the others (such as healthcare and long-term care), which may often be unintended and, most likely, unpredictable.

For example, a change in the state pension age (SPA) is a policy intervention that targets the pension system, with the primary objective of reducing government spending on state pensions and potentially increasing tax revenue from those who remain in work longer (Cribb and O’Brien, 2022). However, predicting the impact of this policy on the pension system and other old-age support systems is not possible at the outset. Consider the effects on the pension system: individuals who would have retired had the SPA not been changed do not simply disappear from the system or immediately reintegrate into the workforce. While some may continue working, others may move onto working-age benefits such as Universal Credit or Disability Support. Recent evidence from England supports this claim. The increase in the SPA for women from 60 to 65 between April 2010 and November 2018, and to 66 for both men and women between December 2018 and October 2020, coincided with an increase in the total incapacity benefits caseload by 330,000 people, equivalent to a 12.3 per cent increase compared with 2008–09 statistics (Office for Budget Responsibility, 2024). Likewise, this policy also resulted in a large increase of 128 per cent in the unemployment rate among women in the affected age group (Gray, 2020).

There is also documented evidence of effects on the healthcare and long-term care systems. This policy has been shown to significantly increase outpatient care costs by about 2.9 per cent among the age group directly affected by the SPA increase (Geyer et al., 2022). Similarly, for the long-term care system, an increase in the SPA could lead to increased demand for formal long-term care due to an overall shift from highly intensive informal care provision to less intensive care provision, driven by the need to remain in work (Carrino et al., 2021; Fischer and Korfhage, 2021). This shift is equivalent to a decline of 2.1 hours per week in the provision of informal care for an average increase of 10 hours of work per week (Understanding Society, 2023), or a decline of 6.3 hours per week in care time for an increase in work time of 30 hours per week due to a rise in the SPA, valued at around £6,500 per year per caregiver at a rate of £20 per hour (Carrino, 2022).

Given this example and the practical implication for policy making that targets systems that may be interconnected with other systems, the key question remains how sustainability can be achieved. This study seeks to set the foundations for the framework that would enable thinking about the sustainability of old-age support systems by synthesising evidence from different fields on how complexity is defined, its properties, and how sustainability can be achieved.

# Method

This review aims to answer two research questions:

1. How are complex systems portrayed across various disciplines?
2. What holistic approaches to the sustainability of complex systems exist across various disciplines?

We adopted an integrative approach to systematically capture literature from a broad range of disciplines and comprehensively uncover existing patterns or themes (Whittemore and Knafl, 2005; Gough et al., 2012).

## Literature Search

We conducted a literature search using the three search strings in Table 1 across the following databases: Proquest - International Bibliography of the Social Sciences (IBSS); SCOPUS; Web of Science; PubMed; IEEE Xplore.

**Table 1: Search Strings**

| String | Search terms |
|---|---|
| Complex systems | ("complex system*" OR "complex adaptive system*" OR "interconnected system*" OR "interlinked system*" OR "adaptive system*" OR "coupled system*" OR "system* of system*" OR "nonlinear system*" OR "chaotic system*" OR "self-organizing system*" OR "multi-level system*" OR "nested system*" OR "dynamic system*") |
| Sustainability | ("sustainability" OR "sustainable development" OR "resilience" OR "long-term viability" OR "system* transition" OR "sustainable transformation" OR "strategic sustainable development" OR "backcasting" OR "The Natural Step" OR "adaptive capacity" OR "transformative change" OR "transition management") |
| Holistic approach | ("system* thinking" OR "holistic" OR "integrative" OR "transdisciplinary" OR "interdisciplinary" OR "cross-sectoral" OR "conceptual") |

In generating these search strings, one of the reviewers initially identified a few key studies across several disciplines, then, with the help of AI (ChatGPT), identified keywords in those studies. These keywords were used to search for similar topics across various disciplines without restrictions. Based on a text analysis across the disciplines, two reviewers further identified approximate synonyms to the initially identified keywords. These keywords were piloted, and the ones in Table 1 represent the appropriate middle ground to capture the relevant studies while also maintaining a manageable scope of work.

## Inclusion Criteria and Quality Check

The search was restricted to peer-reviewed literature, including publications in academic journals, books, and peer-reviewed conference proceedings, written in English and published from 2000 onward. This date restriction provides a sense of the literature's evolution over the past two decades, while also focusing on contemporary rather than distant historical content.

In addition, the literature search was not restricted to any geographical origin or methodology. As such papers that are both theoretical or quantitative, including those that use data simulations, to explain complex systems and their sustainability were included. Those studies that only describe *what* a complex system is, without addressing *how* system complexity operates in practice within their specific discipline, or do not discuss about the sustainability of such systems, were excluded. Studies without abstracts and grey literature, such as theses and dissertation, and government documents, among others, were not considered because they (i.e., grey literature) are not peer-reviewed academic literature and they will produce little useful material for comprehensive review of this nature (Bulmer Smith et al., 2009).

The inclusion and exclusion criteria are summarised in Table 2 below.

**Table 2: Inclusion and Exclusion Criteria**

| **Inclusion** | **Exclusion** |
|---|---|
| **Publication type:**<br>Peer-reviewed papers, including conference proceedings, because in some disciplines, documents in proceedings are peer-reviewed. | Grey literature, including theses and dissertation, and government documents |
| **Time frame:**<br>Since 2000 onward | |
| **Methodology of paper:**<br>Quantitative, qualitative, theoretical, and data simulation papers. | Narrative papers that only describe *what* a complex system is.<br><br>Narrative papers that do not address *how* system complexity operates in practice within their specific discipline.<br><br>Narrative papers that do not discuss the sustainability of such systems. |
| **Content:** Has any of the keywords ("complex system" "holistic" and "sustainability") in the title, abstract, or keywords. | Does not have any of the keywords ("complex system" and "sustainability") in the title, abstract, or keywords. |
| **Geographical origin:**<br>No restriction. | |
| **Language:**<br>English | |

## Quality Appraisal

To ensure a robust appraisal, our review team consisted of members from diverse disciplines and followed a two-stage appraisal of the selected studies: In the first stage, the selected studies were independently assessed by three reviewers to determine their direct relevance to the review's objectives. This stage aims to further refine the selection by identifying the studies most suitable for in-depth analysis. This screening was based on information provided in the title and abstract, and where necessary, a brief examination of the full text will be conducted to confirm the relevance of each study.

In the second stage, each selected study was independently scored by the reviewers based on a detailed assessment of the methodological quality and robustness. This approach is similar to that proposed by Dhollande et al. (2021). Table 3 presents the assessment form, which outlines the specific criteria used to determine the quality of studies ultimately included in this review.

We only include studies that meet fair or good (i.e., those that score above 50%) quality thresholds. While this approach is systematic and follows different iterative steps to improve the quality of the review and mitigate bias, it is important to note that there is no universally accepted model for completely eradicating biases in this process (Russell, 2005). Nonetheless, the assessments in steps 1 and 2 were independent and conducted in a double-blind manner by two reviewers; when disagreement occurred, it was resolved through discussion to reach consensus within the team.

**Table 3: Assessment Form**

| Types of Study | Quality Criteria | Present (Y/N) |
|---|---|---|
| Theoretical papers | • Focus on complexity or a complex system and its sustainability.<br>• Has an abstract and conclusion<br>• Clarity of the purpose of the theory been developed.<br>• Clarity of definitions of concepts<br>• Clarity of assumptions made.<br>• Clarity of framework.<br>• Clarity of theoretical propositions.<br>• Clarity of conclusions | |
| Quantitative and simulation studies | • Focus on complexity or a complex system and its sustainability.<br>• Has an abstract and conclusion<br>• Clarity of definitions of concepts<br>• Clarity of the research design,<br>• Clarity of methods, data collection/use, and variables included.<br>• Clarity of measures and presentation of results.<br>• Clarity of results presented.<br>• Clarity of conclusions. | |
| Qualitative | • Focus on complexity or a complex system and its sustainability.<br>• Has an abstract and conclusion | |

| | | |
|---|---|---|
| | • Qualitative objective or question<br>• Clarity of definitions of concepts<br>• Clarity of qualitative approach, design, or method,<br>• Description of the context, description of participants and justification of sampling,<br>• Description of data collection, and clarity of analysis.<br>• Clarity of conclusions | |
| All other methods | • Focus on complexity or a complex system and its sustainability.<br>• Has an abstract and conclusion<br>• Clarity of definitions of concepts.<br>• Clarity of the research question<br>• The logical flow of conclusions drawn from the presented evidence. | |

## Data Extraction

We developed a matrix to extract data from the selected studies. The reviewers collected basic information about the studies, including the bibliographical details (author(s), publication year, and discipline), the paper's objectives, and the methodology employed (theoretical conceptualisation, quantitative study, simulation, qualitative, and mixed methods). This tool also responded to the following five key items:

1. The definition of the concept of a complex system or complexity in relation to the specific discipline.
2. The principles, features, or characteristics used to qualify a system as complex.
3. The approaches that have been adopted to visualise or simplify the discussion surrounding complex systems.
4. The meaning of the sustainability of a complex system across disciplines.
5. How can sustainability be achieved?

## Data Analysis

The review employed thematic synthesis to analyse and synthesise data from the included studies, following steps similar to those of related studies (Thomas and Harden, 2008; Tabiano et al., 2015). First, the reviewers familiarised themselves with the data in the matrix by reading its contents thoroughly. Second, they kept notes on emerging patterns and their analytical decisions throughout this process. Third, the sections that recorded data for the five key items were analysed inductively through line-by-line coding within and across studies. Fourth, the reviewers grouped the extracted codes into hierarchical categories and sub-categories and generated descriptive groups that are guided by the five-key items above. Fifth, the reviewers examined these descriptive categories to identify latent themes beyond the original content of the selected studies thereby producing a synthesis that addresses the two research questions guiding this review.

# Results

The database search yielded 6,570 records (see Figure 1). Of these, 1,363 records were removed as duplicates, representing 21%. The remaining records were then subjected to a two-stage screening process. As described earlier, in the first stage, selected studies were independently assessed by three reviewers, resulting in 242 records being retained (equivalent to 4% of the total records). In the second stage, the 242 records were independently scored by the reviewers, and 160 were subsequently excluded for failing to meet the quality criteria. The 82 remaining records included in this review employed diverse methodologies. Most of the articles were theoretical (N = 32, 39%), followed by those employing other methodologies such as policy analysis (N = 25, 30%) and qualitative methods (N = 16, 20%).

As shown in Figure 2, the records come from diverse academic disciplines. 40% of the records are from the broad field of sustainability studies, 9% from environmental science, and 7% from urban studies and health science, respectively, while 4% are from agricultural science, civil engineering and urban planning, and ecology. 3% come from management science and disaster management, while the remaining 20% represent disciplines that each account for 1% of the records, including anthropology, artificial intelligence, bioeconomy, climate science, crisis management, nanotechnology and systems engineering, sociology, system science, tourism, among others.

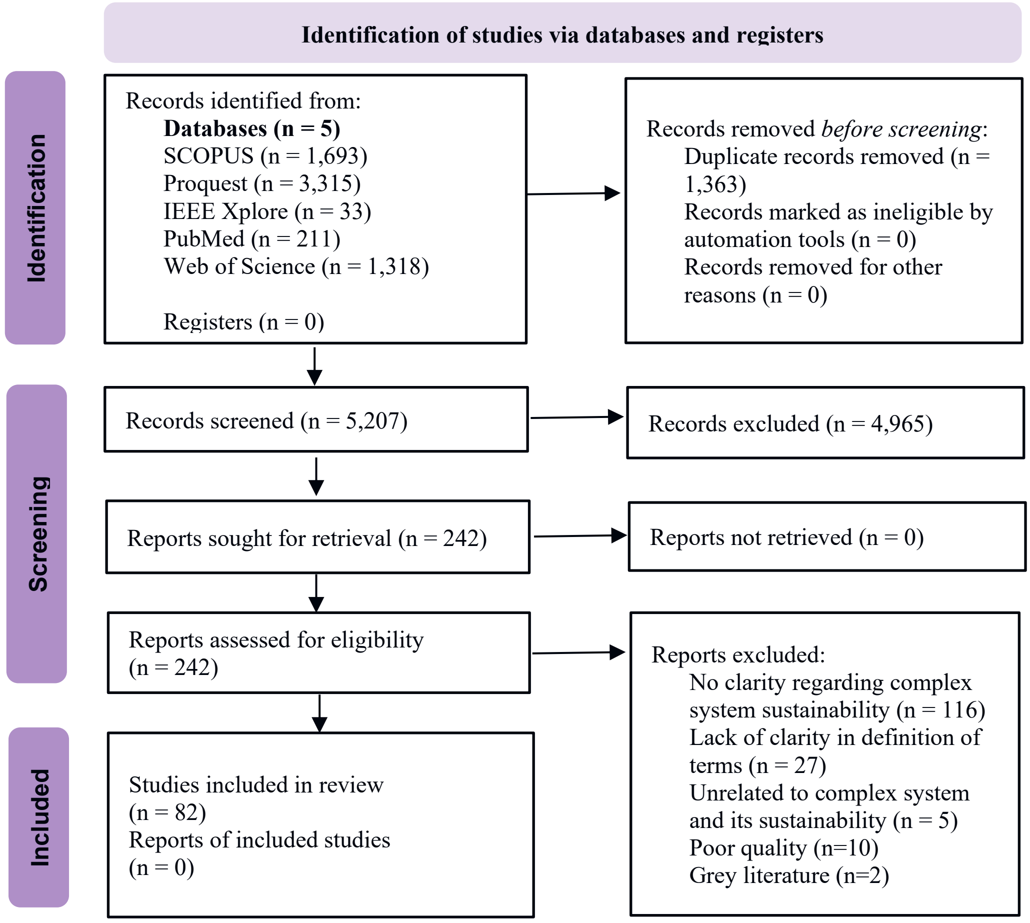


**Figure 1:** PRISMA Diagram

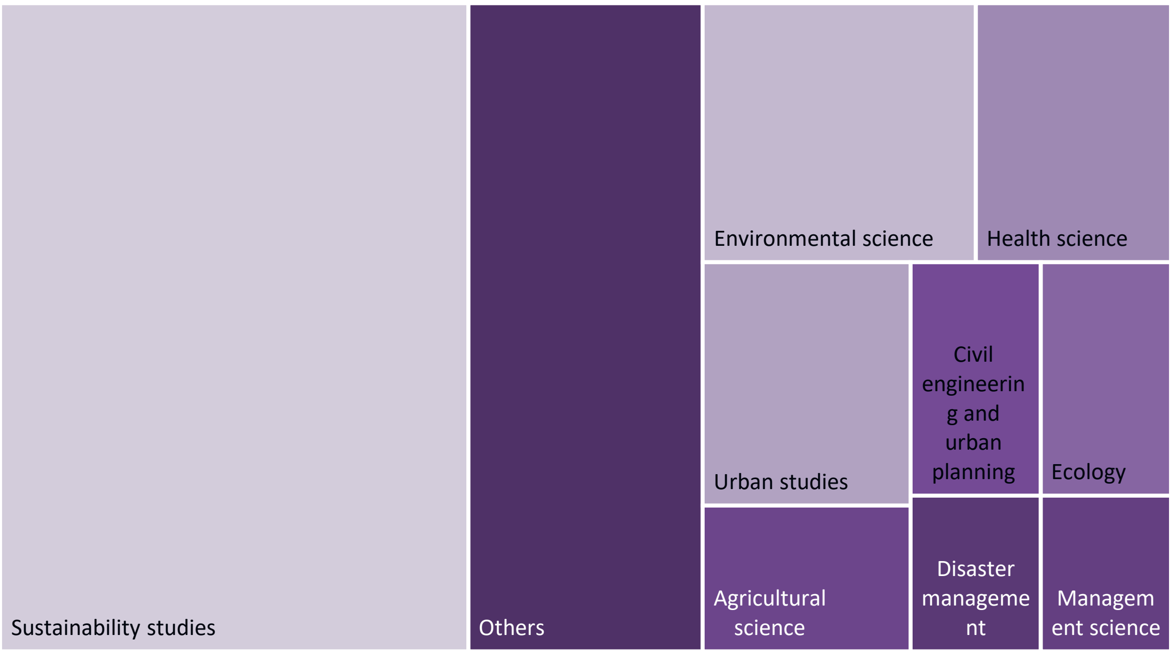


**Figure 2:** Academic Discipline of Records for the Review

## Definition of Complex Systems

From the literature reviewed, complex systems have been identified with different other names, including adaptive systems (Porter, 2008; Yanine and Sauma, 2013; Zhang et al., 2014; Missimer et al., 2017; Talukder et al., 2020; Nel et al., 2018; Ochoa et al., 2025; Smith et al., 2025; Kuhmonen et al., 2024; Zhang and He, 2024; McGreevy and Chia, 2024; de Vries and Axelos, 2021; Esther et al., 2021; Zazueta and Bahramalian, 2021; Dianat et al., 2022), open systems (Gu and Frazer, 2009; Cosgrave et al., 2012; Dianat et al., 2022), holistic systems (Godfrey, 2010; Miller et al., 2025), wicked systems (Cumming, 2011), coupled systems (Nyerges et al., 2014), living systems (Gibbons et al., 2020; Dominici, 2023), chaotic systems (Iwanaga et al., 2020), and nested systems (Esther et al., 2021).

Likewise, it has been defined in diverse ways based on different dimensions of their structure and nature. Authors that focus on the structure of the system have emphasised that a complex system is a system of systems (Phillis et al., 2010). This means that there is a broader system that is composed of other subsystems (i.e., components). Consequently, the whole of the system cannot be understood by reducing it to its individual parts; instead, the broader system and its components must be viewed as an interconnected whole (Porter, 2008; Phillis et al., 2010; Clark and Harley, 2020; De Angelis, 2022; Leslie et al., 2015; Mobus, 2017; Albertí and Fullana-I.-Palmer, 2018; Talukder et al., 2020).

This holistic perspective emphasises that the properties and behaviours of a system emerge from the interactions among its components (Cumming, 2011). These properties and behaviours cannot be reduced to the sum of the components (Godfrey, 2010; Yanine and Sauma, 2013; Filotas et al., 2014; Moore et al., 2021; Chang et al., 2025). In other words, even if each component is fully understood on its own, the overall behaviour of the whole system cannot be understood by focusing on each component, because the system behaviour only emerges when the components operate together.

Those authors that focus on the very nature of complexity are in two groups. The first group define complex systems based on the nature of structural complexity. That is, the number, diversity, and level of interdependence among the components of the system (Beese et al., 2023), including the connectivity and organisation among these components (van den Hooff et al., 2026), which influence the behaviour and properties of the system. The second is dynamic complexity, which considers emergent behaviours and unpredictable interactions among components (Arévalo and Espinosa, 2015; Moore et al., 2021). These two groups emphasise that, inherently, the system is unpredictable (Scriecіu et al., 2022; Malmborg et al., 2022), rendering simple, linear solutions as insufficient to address any emerging issue with the system (Porter, 2008; Godfrey, 2010; Ma et al., 2015; Clark and Harley, 2020; Santana et al., 2024; Zhang and He, 2024; Smith et al., 2025).

The unpredictability of the complex system stems from the fact that the components within the system constantly interact in an environment where small changes in one component can lead to multiple possible outcomes for the system as a whole (Thatcher, 2016; Missimer et al., 2017; Zazueta and Bahramalian, 2021; Dianat et al., 2022; Zhang and He, 2024; Smith et al., 2025). Therefore, understanding such systems often requires a process of "learning your way towards effective action" (Godfrey, 2010), because the attributes of each component continuously evolve and adapt at different scales and levels of organisation (Anderies and Janssen, 2013).

The literature also recognises that despite the structure of the complex system comprising different components or subsystems, the core nature of the system, which distinguishes it from other forms, such as a "complicated system", lies in the inseparability of its interactions and interdependencies. A complicated system, by contrast, consists of interconnected components, for which the outcome of such interaction can be predicted. That is, one can usually predict the outcome of a complicated system by knowing the starting conditions or inputs (Kamensky, 2011). For example, a machinery, such as an aircraft engine, is complicated, because the inputs and results are highly predictable and repeatable (Kamensky, 2011). Unlike a complicated system, whose components can be studied in isolation, the components of a complex system cannot

(Gallopin et al., 2008; Cavallo and Ireland, 2014; Augustsson and Braithwaite, 2019), because the sum of the components does not equal the whole. Consequently, the outcomes that emerge from the interactions among the components of the complex system can only be fully understood only after they emerge (Cavallo and Ireland, 2014).

Figure 3 summarises the core questions to be answered, either yes or no, that distinguishes complex systems from other forms of systems. That is, they are systems with multiple interacting subsystems in which the whole cannot be defined by the characteristics of its parts (subsystems). As the behaviour of the components is interdependent, the outcome of their interaction is unpredictable from the onset, and any new form of the system emerges solely from these interactions. In addition to this definition, the literature also acknowledges that the components of a system can interact with its environment or with other systems external to it (Filotas et al., 2014; Malmborg et al., 2022).

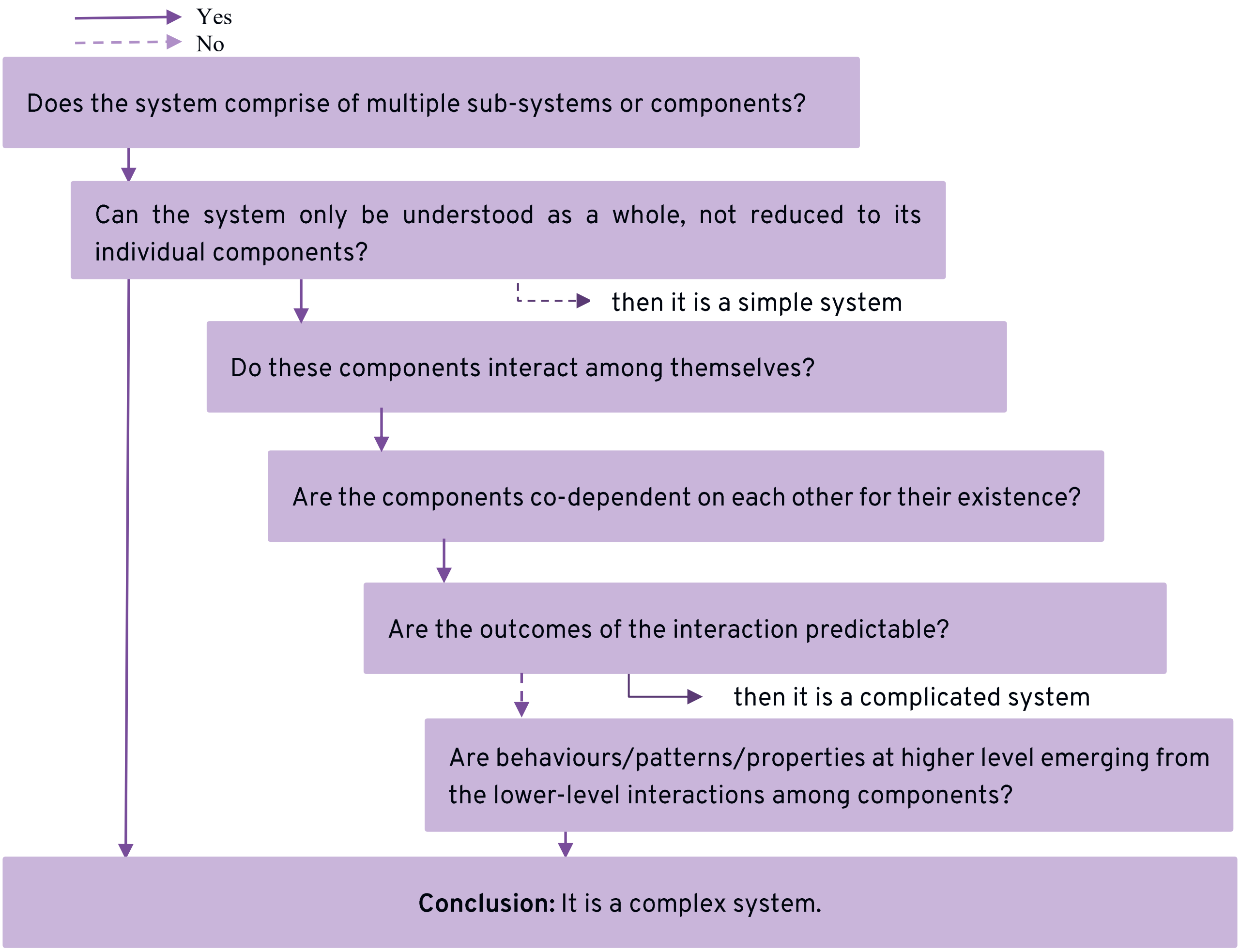

**Figure 3: A Synthesis of the Definition of a Complex System**

## Features of a Complex System

Table 4 describes the core features of a complex system. **Holism and non-monotony** is the first set of features that describe the manner in which to view a complex system. That is, the whole of the system cannot be understood from a collection of its parts (Filotas et al., 2014) or from knowledge that only come from the parts (i.e., components or the sub-systems) that make up the broader system (Motloch and Truex, 2015; James et al., 2021). Instead, any knowledge about the components, which may not necessarily translate into better understanding of the broader system (Cîrnu and Georgescu, 2023), is only used to incrementally improve the components (McGreevy and Chia, 2024).

**Entropy** is the next feature of the complex system. This feature is the natural drift of the system toward disorder, and the changes in its structure to correct such disorders (Arévalo and Espinosa, 2015). As the system's components interact, they generate non-linear feedback, which means the outcome of such interactions becomes unpredictable (Cumming, 2011; James et al., 2021). This feedback could also be in the form of system changes (Santana et al., 2024), which, if accumulated faster than the system can correct them or take a new form (evolve), the system begins to lose order, and the structure of the system weakens (James et al., 2021). Yet, this tendency toward disorder also drives the system forward (Gu and Frazer, 2009). It is through entropy that new forms of the system can emerge, because in complex systems, disorder and the generation of new order move together (Arévalo and Espinosa, 2015; James et al., 2021).

**Self-organisation** and **emergence** are the other features of a complex system. In a complex system, the coordinated structures and behaviours do not arise from central control or a top-down command chain, but from the interactions among components within the system (Gallopin, 2008; Arévalo and Espinosa, 2015; James et al., 2021). These interactions generate coherent patterns at higher hierarchical levels, which then influence the components that produced them (Filotas et al., 2014). Self-organisation is rooted in the adaptation of the components of the system, where interdependencies, functions, controls, and processes within the components shift in ways that can either help the broader system retain its identity (i.e., increase resilience) or push it into a new regime entirely - i.e., a new structure of the system (Peter and Suilling, 2014). The emergence of this new regime reflects a different mode of operation of the system, one that is functionally reorganised (Arévalo and Espinosa, 2015). According to Peter and Swilling (2014), such emergence becomes a “surprise,” because the outcome of self-organisation cannot be fully predicted at the outset.

**Adaptation** and **co-evolution** of the system follow from the interactions among the components of the system. It emerges through successive rounds of feedback based on the interactions among components (Porter and Derry, 2012) or, in response to external inputs (Filotas et al., 2014), which the system uses to adapt and evolve accordingly. While adaptation shares similarities with self-organisation, it differs in that it is typically influenced by forces outside the system (Filotas et al., 2014). This feature of adaptation and co-evolution is core in system science because a system that is able to adapt to any disturbances and still focus on maintaining or improving their intended functions, not necessarily or solely by returning to their original state, will prove much more resilient to future disturbances (Grafius et al., 2020). Hence, the capacity to self-organise and adapt reflects the system’s ability to anticipate, strategically navigate, and evolve without breaking down (Malmborg et al., 2022).

Other key features of a complex system relate to its boundaries, the nested hierarchy that exists within it, and its state of (dis)equilibrium. Regarding the boundaries of a complex system, there is a consensus that it is an open system with porous boundaries (Filotas et al., 2014; De Angelis, 2022). The boundaries are porous because the system is also influenced by external factors, such that interactions that exist both within and outside the system influence its processes and functions (Malmborg et al., 2022). However, Rosas (2017) notes that it is not that the boundaries of the system are entirely open, but that they are not rigid and cannot be easily defined because the components of the system can be simultaneously associated with several other systems.

Hence, the matter of how and where to set the boundaries for the study of a complex system may be driven by the goal of the investigation and the presence and strength of the linkages across the sub-systems. Boundaries may have to be shifted in the process of the study, as new linkages between the subsystems are uncovered.

The components within the system are organised into hierarchies, which emerge from the local interactions among components and give rise to coherent patterns that characterise the system at higher scales (Filotas et al., 2014). According to Gallopin et al. (2008), complex systems are hierarchical, in the sense that each component of the system is a subsystem of a smaller-order system, and the system itself is a subsystem of a larger 'supra-system'. As a result of the continuous hierarchical organisation arising from the constant interaction among the components of systems, a complex system cannot achieve equilibrium and maintains a continuous state of disequilibrium (Thatcher, 2016; Rosas, 2017). Such disequilibrium plays a critical role in generating new order, which is classically termed 'order by fluctuations' (Arévalo & Espinosa, 2015). Hence, maintaining order in the state of continuous disequilibrium requires continuous change, feedback, and adaptation (James et al., 2021) rather than seeking a static balance (Santana et al., 2024).

**Table 4: Key Features of a Complex System**

| Feature | Description |
|---|---|
| **Holism and non-monotony** | A holistic perspective that fosters understanding of systems with interacting components whose global dynamics cannot be calculated by summing the dynamics of individual components (Filotas et al., 2014). The feature of non-monotony implies that increased component knowledge does not provide better system understanding (Cîrnu and Georgescu, 2023). Instead, the knowledge that is constantly built about the system's components and dynamics is used to incrementally improve them (McGreevy and Chia, 2024). |
| **Entropy, Energy Flow, and Order Creation** | In complex systems, entropy reflects the tendency toward disorder and dispersion of energy. This occurs because interactions among system components generate friction, inefficiency, and waste, and if these inefficiencies accumulate faster than the system can correct them, the system loses order — structure breaks down, feedback weaken, and performance declines (Gu and Frazer, |

| | |
|---|---|
| | 2009; Cummin, 2011). According to Cumming (2011), these interactions are "wicked" interactions, which generate non-linear feedback. The mechanism of feedback or change are expressed as coevolution and emergence, such that outcomes that emerge through successive rounds of feedback and successful adaptation enable those networks to coevolve (Porter and Derry, 2012; Anderies and Janssen, 2013). Entropy (disorder) drives evolution and renewal, “order through fluctuations.” Sustainability depends on managing entropy flow (Arévalo & Espinosa, 2015; James et al., 2021). |
| **Self-Organisation and Emergence** | Evidence from Gallopin (2008), Filotas et al. (2014), and Arévalo & Espinosa (2015); suggest that systems produce coordinated structures and behaviour through the interactions that occur among the components of the system, not by any central leader or authority (Jagustovic et al., 2019). That is, such interactions cause coherent patterns, entities, or behaviours to emerge at higher levels of the hierarchy, which in turn, affect the system’s original structure. In other word, self-organisation can firstly be attributed to multi-agent adaptation where the interdependencies, functions, controls and processes of a system undergo changes that either: (1) helps the system retain its overall identity (i.e., increases its resilience); or (2) pushes the system into a fundamentally new regime, which can be predictable or may be a surprise - i.e., emergent (Peter and Swilling, 2014). This new structure comes from emergence, which implies that the system takes a completely different mode of operation, functionally organised and structured in time and space. Peter and Swilling frame this emergence as "a surprise" that couldn't be predicted. |
| **Adaptivity and Co-evolution** | Outcomes that emerge from the interactions of the components emerge through successive rounds of feedback and the system adapts and evolves accordingly (Porter & Derry, 2012). This is one of the core feature of a complex system. Adaptation is adjustments in the behaviour and attributes of a complex system in response to changes in external inputs. It is similar to self-organisation in that it depends on cross-scale interactions but differs in that it is externally driven (Filotas et al., 2014). This feature of adaptation is essential in a complex system because a system that is able to adapt to these disturbances from within or outside the system and still focus on maintaining or improving intended functions, not necessarily or solely by returning to their original state, will prove much more resilient to future disturbances (Grafius et al., 2020). It is the core capacity to self-organise and evolve the behaviour of the system, highlighting the capacity to anticipate and navigate strategically within the system structure (Malmborg et al., 2022). |

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| **Openness** | In complex systems, openness means that energy, matter, and information are exchanged with the external environment through porous system boundaries. Unlike closed systems, the dynamics of a complex system - including all ecosystems - are influenced by outside factors (Filotas et al., 2014). According to Malmborg et al. (2022) a complex system is radically opened, with porous system boundaries and exchange of matter and information between systems. This is because the system is embedded in other systems, with cross-scale interactions influencing its processes and functions. That is, they are influenced by an environment of increasing entropy (Arévalo and Espinosa, 2015). According to Rosas (2017), not that the boundaries of the system are entirely open, but that they are permeable, rather than rigid boundaries, and components of the system can be associated with several systems simultaneously. |
| **Hierarchy and Multi-Scale Interaction** | The components are organised hierarchically. Elements at different levels interact to form an architecture that characterises the system (Filotas et al., 2014). Many complex systems are hierarchical, in the sense that each element of the system is a subsystem of a smaller-order system, and the system itself is a subsystem of a larger order 'supra-system' (Gallopin et al., 2008). In many complex systems, there is strong coupling between the different levels and therefore the system must be analysed or managed at more than one scale simultaneously (Gallopin et al., 2008). But systems at different scale levels have different sorts of interactions, and different characteristic rates of change. Therefore, it is impossible to have a unique, correct, all-encompassing perspective on a system at even one level of the system. |
| **Dynamic Equilibrium and Non-Equilibrium States** | Complex systems operate far from equilibrium because the interaction among their components produce continuous changes (Thatcher, 2016; Rosas, 2017) and a state of continuous and a continuous state of disequilibrium. Maintaining order in this context requires continuous change, feedback, and adaptation rather than seeking for a static balance (James et al., 2021; Missimer et al., 2017). According to Arévalo & Espinosa (2015), disequilibrium plays a critical role in generating new order – which is classically termed 'order by fluctuations.' |

## Approaches Used to Represent a Complex System

Overall, 38 studies describe various approaches to simplifying the description of complex systems. 32% of these studies highlight the use of mathematical and simulation models as essential tools (e.g., Gu and Frazer, 2009; Godfrey, 2010; and Porter and Derry, 2012; Ahram and Karwoski, 2013; Katsumbe et al., 2014; Bataleblu et al., 2024), Meanwhile, 55% emphasise the use of frameworks as another important tool for simplifying complex systems (e.g., Godfrey, 2010;

Anderies and Janssen, 2013; Mangoyana et al., 2013; Wohl et al., 2014; Nel et al., 2018; Kuhmonen et al., 2024; Crona et al., 2025; Frantzich et al., 2025; Smith et al., 2025, among others). The remaining 13% employ case studies as a way to simplify complexity, including studies by Plummer and Fennel (2009), Cumming (2011), Gibbons et al. (2020), Ruggiero et al. (2024), and Chu (2025).

Different mathematical/simulation models have also been used to describe complex systems. A system dynamics model, for instance, was used to identify where and how to intervene to bring about system-wide change, such as interventions aimed at improving sustainability (Crane et al., 2022). This model has also been used to analyse dynamic interactions within a complex system (Sebestyén et al., 2021; Francis and Thomas, 2022). Other modelling approaches include the onion model used by Leventon et al. (2024) to describe the nested structure of interconnections within a complex system. Agent-based modelling (ABM) was applied by Zhao et al. (2023) and Schünemann et al. (2024), among others, as a social simulation method to show how micro-level interactions (i.e., at the sub-system level) generate macro-level (system-level) behaviours and to illustrate policy modelling approaches. Additionally, the uniform network flow model and functional network models have been employed to study interdependent infrastructure failures in real systems (Thacker et al., 2017).

Studies that advocate for the use of frameworks have also employed various approaches to simplify complex systems. For example, Esther et al. (2021) and James et al. (2021) used the complex adaptive systems framework to illustrate the structure of fishery systems and dynamic human-land interactions. While Jagustovic et al. (2019) applied the Distinction, System, Relationships, and Perspective (DSRP) framework to explain the building blocks of a complex system. Sebestyen et al. (2021) adopt the system of systems framework to analyse the interdependencies within a complex system, while Porter (2008) uses the comprehensive organizational model for performance and strategic systems, to help organisations navigate the complexities of modern business. Other studies (Leslie et al., 2015; Smith et al., 2025) employ social-ecological system (SES) frameworks to demonstrate how complex systems operate.

Frameworks have also been applied to clarify the linkages, structures, and rules governing interconnections of sub-systems within a complex system. For example, Grafius et al. (2020) show how frameworks can be used to distinguish between different types of linkages within a complex system. They include physical linkages (direct material connections), cyber linkages (information flows), geographic linkages (spatial interactions), and logical linkages (other forms of connection). Similarly, Esther et al. (2021) use a framework to illustrate four interacting structural elements of a complex system. They include a) boundaries, which define the elements between subsystems; b) temporal and spatial scales, which shape the functioning of elements within the system; c) links, which define the flow of interactions; and d) management levels, which describe hierarchical relationships and cross-level interactions. Jagustovic et al. (2019) use the DSRP framework to articulate the rules governing relationships among system components.

Overall, the studies reviewed offer no clear consensus on a preferred method for simplifying a complex system. The two most frequently used approaches, models and frameworks, have their distinct but complementary advantages. On the one hand, models are relevant for representing dynamic processes and integrating system components, which is particularly important when analysing emergent properties, such as the sustainability of the system that arise from the interactions of the sub-systems (Godfrey, 2010). On the other hand, frameworks are used to describe more complicated relationships that cannot be formalised. They are relevant for visualising the interrelationships or interdependencies that exist within the system or between various systems (Godfrey, 2010; Sebestyén et al., 2021).

The choice of representation and the inclusion of subsystems/components depend on the question being studied or analysed. Crane et al. (2022) makes this distinction, noting that questions related to understanding the causal chains and feedback loops in a system can be represented using system dynamics models (SDMs), whereas questions concerned with the structural patterns that generate certain outcomes or interconnections can be examined using agent-based modelling. Supporting this distinction, Sebestyén et al. (2021) and Francis and Thomas (2022) argue that SDMs are most appropriate for exploring dynamic interrelationships among system components. Zhao et al. (2023) and Schünemann et al. (2024) similarly contend that agent-based models are most relevant for examining emergent outcomes arising from interactions among system components.

## Meaning of the Sustainability of a Complex System

The definition of sustainability by Brundtland (1987) has been the foundational framing for several authors (e.g., Leslie et al., 2015; Mobus 2017; Albertí and Fullana-I.-Palmer, 2018; Talukder et al., 2020; De Angelis, 2022). This definition emphasise that sustainability is meeting the needs of the current generation without compromising the ability of future generations to meet their own. Building on this foundation, studies such as Porter (2008), Phillis et al. (2010), Clark and Harley (2020), and Talukder et al. (2020), highlight sustainability as a system property in which resources, processes, and interactions are managed in ways that support the continuity of the system and minimise its degradation.

A complementary dimension to the definition of sustainability integrates it with resilience. While these two concepts are sometimes used interchangeably, Leach et al. (2018) and Gillespie-Marthaler et al. (2019), argue that resilience functions as a mechanism for achieving sustainability. That is, sustainability can be understood as an outcome or, at best, a property embedded within the system, focused on maintaining the system's capacity to achieve its intended goals over time (Leach et al., 2018). In contrast, resilience refers to cultivating the capacities needed to absorb or adapt to shocks and stressors, as well as to transform or reconfigure the system into a new, desirable state when it can no longer meet the needs for which it was originally established (Leach et al., 2018; Gillespie-Marthaler et al., 2019).

Building on this clarification, Cavallo and Ireland (2014), Missimer et al. (2017), and Ruggiero et al. (2024) conceptualise sustainability as the capacity of a system to withstand, absorb, adapt to, and recover from shocks or disturbances, while potentially emerging stronger. Similarly, Wohl et al. (2014) and Filotas et al. (2014) stress that sustainability involves system's ability to return to, or maintain proximity to, a pre-disturbance state. That is, a sustainable complex system is one that preserves its key structures and functions following disturbances (Missimer et al., 2017; Kuhmonen et al., 2024; Chang et al., 2025; Miller et al., 2025). Based on this view, resilience becomes both a mechanism and an outcome of a sustainable system (Ruggiero et al., 2024). This outcome should not be viewed as a static goal or a fixed end, but as an ongoing, non-terminal path of development and adaptation of the system and its components to changing conditions as needed (Porter and Derry, 2012; Yanine and Sauma, 2013; de Vries and Axelos, 2020; McGreevy and Chia, 2024; Ochoa et al., 2025; Rouchitsas and Johansson, 2025).

Given these clarifications, sustainability therefore begins at the point where the system demonstrates a stable capacity to maintain its core purpose through continuous adaptation. It first emerges at the point of transformation (Zhang et al., 2014), which is a fundamental shift in the behaviour of components of the system, in such a way that they influence the broader system to continue to serve the goal for which it was created (Zhang et al., 2014; Leventon et al., 2024; Orr, 2025). Sustainability also begins at the point of "functional distribution", where disturbances that originate from one subsystem are dispersed across multiple subsystems (i.e., cross-scale distribution), allowing the broader system to buffer against lost or disrupted functionality (Sundstrom et al., 2014). Together, these points mark the transition towards a more adaptive pattern of system-wide resilience that is a prerequisite for sustainability (Zhang et al., 2014; Sundstrom et al., 2014).

This process of adaptation entails that the components within the system constantly interact to establish trade-offs among themselves to foster self-organisation (Nyerges et al., 2014; Peter and Swilling, 2014) and the robustness of the broader system (Jagustovic et al., 2019). Such trade-offs often concern different forms of capital - broadly understood as the resources or assets that enable the system to function - since different components of a system rely on different types of capital for their viability (Gillespie-Marthaler et al., 2019). Weak sustainability assumes that these capitals are substitutable, so long as the total capital stock is maintained (Nourry, 2008; Gillespie-Marthaler et al., 2019). Strong sustainability rejects this substitutability, arguing that certain capitals are non-replaceable and therefore must be maintained without relying on compensation from other forms of capital (Dietz and Neumayer, 2007; Gillespie-Marthaler et al., 2019).

## How Can the Sustainability of a Complex System be Achieved?

The literature reviewed proposes multiple dimensions through which the sustainability of complex systems can be achieved. In this section, we synthesise these dimensions into a set of themes.

### *Making Sustainability an Emergent Property of the Complex System*

The first dimension is embedding sustainability as an emergent property of a complex system. That is, sustainability does not emerge from a predetermined goal or a targeted intervention, but from the interactions, feedback, and adaptive behaviours of the system's components (Leach et al., 2018; Jagustovic et al., 2019). In this framing, sustainability becomes a natural outcome in response to any shocks (i.e., input) to the system when there is effective dialogue supported by strong relationships among the system's components (Porter, 2008; Cavallo and Ireland, 2014). This dialogue, defined as the structured exchange of ideas, knowledge, perspectives, and feedback among the components in a system, functions as a coordination mechanism through which information is shared, expectations are aligned, and feedback loops are reinforced (Crona et al., 2025). For this dialogue to be meaningful, it should be participatory and acceptable to all components of the system (Cumming, 2011; Rosas, 2017; Peter and Swilling, 2014; Moore et al., 2021).

The dialogue should not be a one-off conversation but a continuous, interactive process that enables the system to learn, adapt, and self-organise in response to shocks (Cumming, 2011; Cosgrave et al., 2012; Peter and Swilling, 2014; Miller et al., 2025). As this process unfolds, it generates the shared knowledge needed for informed decision-making and adaptive innovation among the components (Cumming, 2011). Such innovation, understood as a significant shift in the behaviour of the components, emerges naturally, not as a planned or optimum solution (Mangoyana et al., 2013), but from strengthened relationships (Cavallo and Ireland, 2014), shared understanding (Malmborg et al., 2022), and aligned incentives (Crona et al., 2025) across sub-systems. In other words, the depth of the relationship across the components of the system, cross-scale learning, and continuous feedback will collectively support the emergence of sustainability.

Moreover, the consistent dialogue among the system's components builds collective intelligence (Bataleblu et al., 2024), which enhances the system's capacity to sense early signals of disturbances. This collective intelligence leads to the identification of tipping points, leverage points, and the detection of thresholds within the system (Posner and Stuart, 2013; Wohl et al., 2014; Dawson et al., 2017). Although these concepts are sometimes used loosely in the literature, they refer to different concepts. Thresholds and tipping points denote critical conditions beyond which system behaviour shifts, often abruptly and across different unpredictable directions in the case of tipping points (Dianat et al., 2022), while leverage points indicate places within a system where small, targeted interventions can generate disproportionately large effects (Posner and Stuart, 2013).

### *Create Buffers around Thresholds*

Beyond identifying the thresholds and tipping points within a system, actively working to avoid them and build buffers around them is also an integral path towards a more sustainable complex system (Dianat et al., 2022). If buffers are not created around thresholds or actively working to avoid the system cross the thresholds, the system is likely to be fundamentally transformed into a new regime once it crosses this point (Dianat et al., 2022). That is, the system is likely to significantly change in its structure and functions once the threshold is crossed.

Such a transformation can either lead towards sustainability or not (Clark and Harley, 2020). To prevent such significant transformation of the system, particularly since one cannot predict the outcome of the new regime, it is important to create buffers around the thresholds (Dianat et al., 2022). These buffers increase the system's ability to absorb disturbances without exceeding its threshold. As Kuhmonen et al. (2024) note, many changes may take place, but the 'magnetic core' of the regime of the system does not allow major breakaways.

From the literature reviewed, there are two approaches to creating buffers around system thresholds. The first is establishing a functional distribution buffer within the system (Sundstrom et al., 2014). This is achieved by strengthening the interconnections among system components (or subsystems), so that disturbances originating in one subsystem are dispersed across multiple subsystems (Sundstrom et al., 2014). As Dianat et al. (2022) note, it would require a thorough understanding of the system in order to identify which feedback are, or were, dominant and what actions or drivers can break undesirable feedback loops or help recreate lost ones. In other words, understanding feedback loops is the knowledge needed to ensure that the connections being strengthened within the system for effective functional distribution are the right ones.

The second is the adaptive capacity buffer. This implies continuous balancing of trade-offs between different forms of capital or resources within the system so that it can adapt to disturbances (Gillespie-Marthaler et al., 2019). It would require a sustainability assessment, broadly defined as clarity about the system's sustainability goal and the mechanisms to measure it (Philis et al., 2010). However, as Gillespie-Marthaler et al. (2019) state, such assessment would focus on risks (in terms of a system's impact upon its critical resources) and the system's ability to remain within the paradigm. That is, the intended and overarching goal that the system is seeking to achieve (Posner and Stuart, 2013; Leventon et al., 2024).

### *Integrating Legacy with New Policy*

Every existing system is founded on a pre-existing structure that may have evolved over time into more intricate structures due to the complex interactions among its components (Zhao et al., 2023; Santana et al., 2024). These interactions help to identify leverage points where innovative interventions can potentially shift the overall behaviour of the system (Posner and Stuart (2013). However, for such interventions to result in sustainability, any new measures introduced to address disturbances to the system must align with the foundational focus or original intent of the system (Philis et al., 2010).

It is important to note that these foundational or historical structures should not be rigidly enforced in ways that perpetuate silos or sustain a system that no longer serves the needs it was formed to serve (Grafius et al., 2020; Crane et al., 2022). Rather, the system should evolve by enabling opportunities through careful and informed consideration of how interventions allow it to adapt to changing conditions (Grafius et al., 2020). In this way, innovations or any new interventions targeting the system should not only address emerging challenges but also align with and build upon the system's foundational structures. This would ensure the system's continuity while components adapt to shocks or disturbances.

### *Defining Benchmarks and Clarity of Sustainability Goals*

In complexity science, benchmarking refers to assessing the performance of a system across a range of possible scenarios (Francis and Thomas, 2022) and comparing these performances against agreed goals that are developed through an iterative learning cycle both within and outside the system (Augustsson and Braithwaite, 2019; Moore et al., 2021). In other words, benchmarking means testing how a system performs under different conditions and continually updating its goals based on what is learned over time, both from inside and outside the system. It is important to note that this should be an ongoing learning process and not a one-time comparison.

Establishing such a benchmark is essential for evaluating trends and deviations in the performance of sub-systems or the broader system, and for exchanging ideas on best practices (Alberti and Fullana-I.-Palmer, 2018). Benchmarking also enables the tracking of system responses to specific actions at a specific leverage point (Posner and Stuart, 2013), supporting corrective action through iterative processes (Clark and Harley, 2020), and ensures comparison of scenarios to weigh the cost and benefit of actions taken towards sustainability (Moore et al., 2021).

For benchmarking to be effective, the agreed-upon goals must be clearly articulated, defined, and measurable (Haller and Koeleian, 2003; Leach et al., 2018; Jagustovic et al., 2019). Achieving this clarity requires feedback and interaction among system components to reach an understanding acceptable to all (Jagustovic et al., 2019). Without such clarity, progress toward sustainability can be hindered by different perceptions of the goals and how they should be achieved, particularly in systems where the behaviour of one component influences others (Levy et al., 2018). Components within the system operate according to their core values and principles (Esther et al., 2021), and when mismatches arise among sub-systems, clearly agreed-upon goals provide a basis for reconciling these differences (Zazueta et al., 2021).

# Implications for Policy

This study sought to set the foundations for the framework that would enable thinking about the sustainability of old-age support systems by synthesising evidence from different fields on how complexity is defined, its properties, and how sustainability can be achieved. As shown, understanding complex systems requires focusing on the interactions between components rather than the components in isolation. The review also demonstrates that sustainability cannot be imposed through predetermined goals or top-down interventions that target the components of the system. Instead, it emerges from the quality of interactions, feedback loops, and adaptive capacities within system.

These findings have significant policy implications. First, policies must move away from linear, siloed interventions that target single components of the system. Instead, they should focus on improving the quality of interactions among system components, so as to allow for sustainability to emerge naturally. This is such that any sustainability innovation to the system would naturally emerge from the interactions that exist among the components.

Disregarding the interaction among the system's components and imposing sustainability goals or interventions risks pushing the system towards unintended tipping points. This is because policy interventions are imposed without regard to the specific leverage points within the system, that is, points within a system where small, targeted interventions can generate disproportionately large effects that may shift the structure and behaviour of the system into an entirely new state (i.e., a new regime) so that the system does not return to its previous form. Hence, there is a need to prioritise strengthening relationships and information flows across the components of the system, so as to enable continuous dialogue and create conditions in which the system can self-organise and adapt, thereby preventing it from shifting to a less desirable regime.

The second implication is that, while complex systems have porous borders, policymaking by setting and imposing sustainability goals therefore becomes inefficient. To address this concern, policymaking should focus on the quality of interactions between components, so that some sustainability features emerge naturally from these interactions. At the same time, feedback from any sustainability goals that are deliberately introduced into the system, or its components should be monitored. Once such feedback among the components is well managed, such that any new behaviour of the system's components arising from the intervention does not interfere with the system's ability to continue delivering its core functions, sustainability becomes the system's natural ability to maintain balance, even when new goals or policy interventions are introduced.

The third implication is the need to identify thresholds within systems and create buffers around them. As shown in the review, buffers can be created by establishing a functional distribution within the system and through adaptive capacity. That is, the continuous balancing of trade-offs between different forms of capital or resources within the system so that it can adapt to any shocks originating from one or all subsystems.

One real-world example of adaptive capacity for the healthcare and long-term care system in England is the Better Care Fund, which is a single pooled budget for health and social care services to work more closely together in local areas, based on a plan agreed between the NHS and local authorities (Bennet and Humphries, 2014). However, the broader question relating to the complex old-age support systems is whether other forms of resources and capital (e.g., human capital) within the three systems can be adaptively used to address needs across systems, such as training care workers to perform other basic healthcare roles or reconceptualising the winter fuel payment not solely as income support for heating costs, but as a preventive intervention that reduces cold-related healthcare issues and the subsequent need for long-term care due to an increased risk of falling, among others.

# Conclusion

The purpose of this integrative review is to describe how complex (and potentially interlinked) systems are portrayed, and to examine the holistic approaches to the sustainability of such systems across various disciplines. Although the body of literature employing different methodologies to describe complexity is growing, the consideration of complexity in social policy discussions is only beginning to take shape. This is because most socio-economic systems are becoming increasingly complex (Balland et al., 2022), such that interventions targeting one component may yield non-linear responses in that component or in other interconnected components. Hence, policy design in the face of such complexity would benefit from a holistic cross-disciplinary synthesis of the concept of complexity and its underlying principles, to avoid policies that target sustainability through isolated and narrowly focused strategies.

This review is not without its limitations. First, the literature search was restricted to electronic databases, which may have limited the scope of our sample. Consulting librarians may have widened the scope of our literature search; however, due to resource constraints, we were unable to obtain their assistance. The search was also restricted to English due to the reviewers' language proficiency. This restriction may have unintentionally contributed to language bias in the review (Cottrell and Duggleby, 2016).

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