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EDITED BY

Md Rayhan Shaheb,
Central State University, United States

REVIEWED BY

Cecilia Elizondo,
El Colegio de la Frontera Sur, Mexico
Lucas Skoufa,
Griffith University, Australia

*CORRESPONDENCE

N. Sobratee-Fajurally
✉ sobrateenafisa@gmail.com

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A cybernetic framework for transformative food system change: sustainable landscape management in West and Central Africa

N. Sobratee-Fajurally^{1*}, O. Cofie², R. Slotow³ and
T. Mabhaudhi^{4,5,6}

¹IWMI, Huntingdon, Cambridgeshire, United Kingdom, ²International Water Management Institute, Accra, Ghana, ³Centre for Functional Biodiversity, School of Agriculture and Science, University of KwaZulu-Natal, Pietermaritzburg, South Africa, ⁴Centre on Climate Change and Planetary Health, Department of Population Health, London School of Hygiene and Tropical Medicine, London, United Kingdom, ⁵Centre for Transformative Agricultural and Food Systems, University of KwaZulu-Natal, Pietermaritzburg, South Africa, ⁶United Nations University, Institute for Water, Environment and Health (UNU-INWEH), Richmond Hill, ON, Canada

The multiple socio-ecological dimensions of sustainable landscape management, along with potential cross-boundary effects and co-evolving societal conditions, require research evaluation approaches that consider complex projects as viable organizational systems rather than a collection of stand-alone work-streams. This study analyses the co-design phase of the Transforming Agri-Food Systems in West and Central Africa (TAFS-WCA) Initiative by applying the Viable System Model (VSM) as a cybernetic framework for organizational analysis. Using the Initiative's proposal and Theory of Change as the reference structure, the analysis identifies three nested organizational levels: Initiative, Work Package and Output, and summarizes how the five VSM functions at each level interact to shape operational processes, coordination mechanisms, strategic foresight and governance. Moreover, an adapted Rummler-Brache Nine Box Model is applied to the VSM diagnosis to support streamlined examination of performance expectations, process design, and capability requirements across the nested levels. This dual framing supports a structured and systemic interrogation of the Initiative's organizational design. It highlights how the Monitoring, Evaluation, Learning and Impact Assessment (MELIA) functions may act as potential feedback pathways linking operational performance (S1) with managerial oversight (S2, S3, S3*) and strategic adaptation (S4, S5). The cybernetic interpretation, therefore, positions MELIA as a visible mechanism through which reflective and accountability processes can filter, strengthen and redirect information flows across recursive levels. The analysis then focuses on Work Package (WP) 3, which synthesizes evidence from multiple WPs to develop sustainable landscape management plans and a Water Decision Support System. By matching WP3's expected deliverables with the outputs and Activities from other WPs and interrogating these relationships through the VSM, the analysis clarifies how interdependencies across the nested organizational levels may influence WP3's ability to mobilize evidence. This structured approach offers a clearer understanding of how WP3's integrative role may contribute to system (Initiative)-wide adaptive capacity. This study provides a reproducible methodology for examining, during the co-design phase, how governance, coordination and performance dynamics can be aligned within sustainability initiatives operating under complex and evolving conditions.

KEYWORDS

co-design, complex project-oriented organizations, food system transformation, monitoring, evaluation, learning and impact assessment, nested governance systems, systemic learning, transdisciplinary interventions, Viable System Model

1 Introduction

Efforts to implement sustainable and resilient food systems are increasingly being led by large research organizations such as the Consultative Group on International Agricultural Research (CGIAR), which brings together diverse expertise to address complex sustainable development goals (Coccia et al., 2022; Heilmann et al., 2022; McIntire and Dobermann, 2023; Meinke et al., 2023; Nelson and Morton, 2020). These are often described as project-oriented organizations (Chronéer and Backlund, 2015; de Groot et al., 2020, 2022) operating within environments that are systemic, multi-layered, and subject to constant change and variety (Barile and Saviano, 2018; Espinosa et al., 2023; Leon-Romero et al., 2024). In this context, “variety” refers to the wide range of differences, fluctuations, and changes found both within the organization and its environment, including differences in people, processes, technologies, local conditions, and the unpredictable ways these factors can interact and evolve (Cardoso Castro, 2019). Within such settings, the characteristics of systems, such as their ability to self-organize, adapt, and generate new, emergent features, shape how sustainability projects unfold over time. These systemic properties must be coordinated across multiple stakeholders and disciplines to co-develop sustainability interventions and scale socio-ecological innovations (Barile and Saviano, 2018; Midgley and Lindhult, 2021). Achieving the United Nations Sustainable Development Goals (SDGs) depends on such complex cooperation, and projects are often transdisciplinary in nature (Belcher and Halliwell, 2021; McGregor, 2014). However, the dynamic and unpredictable course of these projects means that new forms of self-regulation and organizational learning are needed to maintain cohesion and strategic focus in program design and implementation, and to ensure that resources are deployed for greatest impact (Battisti, 2018; Hodgson, 2012; Holzer et al., 2019; Liboni et al., 2023; Tejada et al., 2019). The Viable System Model (VSM), developed by Stafford Beer, provides a foundation for understanding and evaluating organizational effectiveness in a range of settings, from business and innovation to health, community, and urban food systems (Akmal et al., 2023; Devine, 2005; Espinosa and Duque, 2018; Espinosa et al., 2023; Leon-Romero et al., 2024; Núñez-Ríos et al., 2020; Tong et al., 2018). The VSM can be used in the ‘design’ mode – to structure new projects so they are adaptable and effective from the outset (Achterbergh and Vriens, 2011; Beer, 1984; Lowe et al., 2020; Rezk and Gamal, 2019) – or in a ‘diagnostic’ mode – to assess and improve existing structures (Lechler et al., 2022; Rahayu and Zulhamdani, 2014; Schwaninger, 2015, 2019).

In this conceptual paper, we show how the proposal for the Transforming Agri-Food Systems in West and Central Africa (TAFS-WCA) Initiative, which is in a CGIAR format, can be interpreted and planned as a Viable System. The TAFS-WCA project proposal is analyzed to demonstrate how its main features – Outputs, Work Packages, and the Monitoring, Evaluation, Learning and Impact Assessment (MELIA) Plan – can be

mapped onto the VSM framework to streamline functions and decision-making across multiple organizational levels. A diagnostic approach (Jackson, 2003) is used to examine how these elements form nested systems and subsystems, connected by feedback and learning, with particular focus on Work Package 3, which must coordinate inputs from across the Initiative to deliver inclusive innovation plans and support practical tools such as a Water Decision Support System within the Water-Energy-Food-Environment-Health nexus. The objectives of this paper are to:

- (i) Present a focused scoping review of literature on Viable System Model applications in sustainability research, highlighting key trends, gaps, and insights
- (ii) Explain the principles of the VSM and show how the core constructs of Operations (O), Management (M), and Environment (E), as well as the five systems, are relevant for structuring complex sustainability projects
- (iii) Map the organizational features of the TAFS-WCA Initiative – including Work Packages, Outputs, and the MELIA PLAN – onto a recursive VSM framework to illustrate their interconnections and feedback mechanisms
- (iv) Use Work Package 3 as an example of the WEFH nexus to show how the VSM can help integrate transdisciplinary contributions and support system-wide coordination and learning

2 Methods

2.1 Scoping review

A PRISMA-ScR scoping review was conducted using the Population-Concept-Context (PCC) framework (Gupta et al., 2023; Peters et al., 2015). The Population comprised organizations and governance or socio-ecological systems analyzed through the Viable System Model (VSM). The Concept focused on VSM and organizational cybernetics and the Context refers to sustainability applications across organizational, environmental and governance domains. A structured search was conducted in the Web of Science Core Collection (SCI-EXPANDED, SSCI, A&HCI, ESCI), dated 28 November 2025 using the query:

TOPIC = “Viable System Model” AND sustainab*.

The search identified 82 records ($n = 82$), and following screening according to the PCC criteria and exclusion of certain document types, namely 12 conference proceedings, one non-English article and one book review, 68 articles ($n = 68$) were retained. A descriptive conceptual synthesis of the evidence was undertaken to capture study characteristics, sustainability domains, VSM functions, methodological orientation, and key conceptual boundaries.

2.2 Context

The paper is based on the premise of inclusive landscape management whereby equal access to and proper use of land and water resources is a prerequisite to building a healthy, productive, and One Health-sensitive environment for resilient agri-food systems and livelihoods. The present conceptual analysis focuses on the co-design phase of the Initiative, when expected deliverables, Work Package interdependencies, and integration requirements need to be clarified before implementation. This timing is important because the Initiative's intended outputs are not expected to be delivered through isolated Work Package activities alone, but through coordinated evidence flows, shared feedback mechanisms and integrated planning across the program. The study, therefore, is not an implementation evaluation, but uses the TAFS-WCA Initiative as an integrated case to show how a VSM-based analytical framing can examine whether the organizational conditions for such coordinated delivery are present at the design stage. The TAFS-WCA Initiative forms part of the Regional Integration Initiative of the Consultative Group for International Agricultural Research (CGIAR). It consists of five Work Packages (WPs) delivered over three years. The project is being implemented in six countries: Ghana, Ivory Coast, Nigeria, Rwanda, Burundi, and the Democratic Republic of Congo (Figure 1). The Full Proposal Document published by the Consultative Group for International Agricultural Research (CGIAR) is the primary source of information to explore the type of information WP3 requires and needs to deliver to demonstrate measurable impact (CGIAR, 2021). Work Package 3 (WP3) is essentially viewed as the transdisciplinary component of the TAFS-WCA project as it transforms research outputs generated from other WPs into innovation bundles such as a Water Decision Support System and sustainable landscape management plans. WP3, therefore, seeks to combine participatory tools and citizen science to co-develop and implement inclusive landscapes owned by the communities that enable the sustainable scaling of bundled land, water, aquaculture, and climate-smart agronomic and digital innovations. WP3 proposes

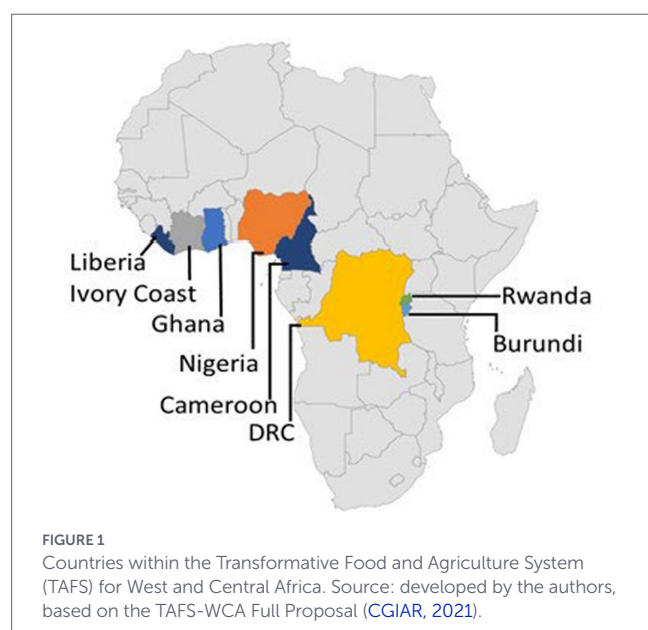
to (i) co-establish the status and progress of landscape management for sustainable intensification; (ii) design adaptive socio-ecological landscape management plans that are One Health-sensitive and embedded in local and national governance systems; (iii) develop a near real-time water resources decision support system (WRDSS) to strengthen landscape resilience planning and investment; (iv) deploy context-specific integrated land, water, fish, crop and agronomic innovations at scale and (v) deploy market-driven circular bio-economy innovations to reduce pressure on water and land resources while mainstreaming One-Health approaches in planned innovations (CGIAR, 2021).

The primary analysis is therefore limited to proposal-stage and co-design documentation. While not used as a primary data source for the VSM diagnosis, the 2024 Annual Technical Report is referenced in the Discussion as an implementation-stage reporting source that could support future empirical validation.

The Theory of Change (Appendix 1a) in the TAFS-WCA Initiative indicates that to deliver the outcome of each WP successfully and be relevant to the United Nations Sustainable Development Goals (United Nations Department of Economic and Social Affairs, 2020), most outputs depend on and/or are dependent on some outputs from another WP (CGIAR, 2021). Therefore, merely ensuring the delivery of outputs within a single WP is not sufficient to demonstrate impact at scale because the aim is to deliver an Innovation or a basket of Innovations or, as in WP3 (Appendix 1b), a sustainable landscape management plan that incorporates an inclusive Water and Land Resource Decision Support System that supports One Health-sensitive baskets of innovation. Moreover, the TAFS-WCA Initiative includes a dedicated Monitoring, Evaluation, Learning and Impact Assessment (MELIA) Plan, targeted at delivering the Innovation Platforms (IPs). The aim is to demonstrate that although TAFS-WCA is a complex project, a systemic design can help clarify how different WPs need to be integrated, monitored and adapted to deliver their intended outputs.

2.3 Analytical approach

The study applies a deductive-abductive analytical approach to examine the TAFS-WCA Initiative as a proposed organizational system (Robinson and Bailey-Rodriguez, 2026; Timmermans and Tavory, 2012). The deductive logic is based on the predefined structure of the Viable System Model (Beer, 1981), specifically the distinction among organizational functions, namely Operations, Management, and Environment, and the five core functions of S1, S2, S3, S3*, S4, and S5. These categories serve as an analytical framework for interpreting the Initiative's proposal-stage architecture, including Work Packages, Outputs, Theory of Change, and MELIA arrangements. The abductive component consisted of developing a plausible system explanation of how these organizational elements may interact to support coordination, accountability, learning and strategic adaptation. This approach is appropriate because the study does not aim to measure implementation performance empirically but to generate a theoretically informed diagnostic interpretation of program design. The resulting VSM diagnosis should therefore be understood as an *ex-ante* conceptual analysis that can guide future empirical validation logic during implementation.



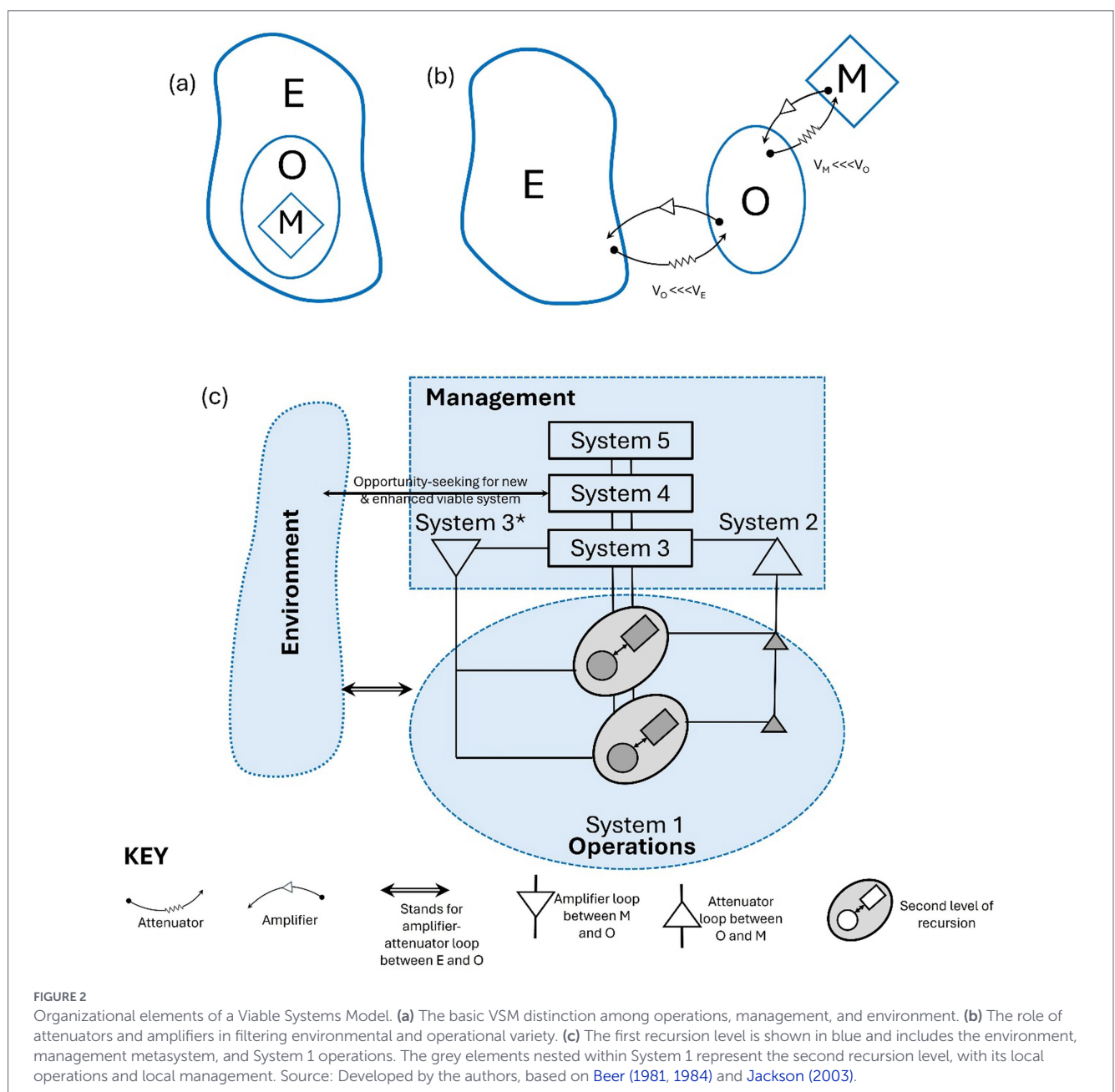
2.4 Application of the cybernetic framework

2.4.1 Theoretical background of the Viable System Model (VSM)

According to Beer (1981), an organizational system is said to be viable if it survives, remains united, maintains stability while adjusting to both internal and external conditions, and possesses mechanisms and opportunities for growth, learning, development, and adaptation, which allow it to become increasingly effective within its environment. Thus, all viable organizations are viewed as consisting of firstly, an Operational part, O, which performs the primary activities, and a metasytemic, i.e., higher management (M), providing the services needed by the operational units so that they cohere into a greater whole, and secondly, an environment, E, which is in constant interaction with both the Operation and the

Management (Figures 2a,b; Jackson, 2003; Vahidi et al., 2019a). Such viability is contingent on having a balanced relationship with the Environment (E) in which it operates and from the existence and interactions among five key organizational functions: System 1 (Primary operations or divisions), System 2 (Coordination mechanisms for learning), System 3 (Operational management for synergy) and System 3* (Audit mechanisms as means of accountability for S3), System 4 (the intelligence/knowledge base for strategic management) and System 5 (normative management for policy definition) (Espinosa, 2023; Jackson, 2003; Lowe et al., 2020).

Moreover, the VSM recognizes the recursive nature of systems, that is, systems exist holonically or in heterarchies (Beer, 1984). This means that systems can be understood as nested systems with each part functioning as a system in its own right. This is similar to the nested arrangement of Russian dolls, which is commonly



applied to explain that in such systems, the mode of organization at a higher level is consistently repeated in other parts of the system, exhibiting the same organizational characteristics and hence ensuring information feedback and systemic viability (Hoverstadt, 2020; Lowe et al., 2020). Thus, in an organizational structure where the System 1 operation may have several sub-operations embedded within it, each one of which could potentially have an independent existence, i.e., could be a viable system itself, these sub-operations will have their S2, S3, S4 and S5 which are usually denoted as the localized management, M. To illustrate this, in Figure 2c, a second level of recursion can be observed in System 1, with its own localized Operations (circle) and localized management function (rectangle).

Beer (1981) applied the concept of variety, known as the Law of Requisite Variety, to explain the selective action that organizations aiming to be viable ought to adopt. This helps select the necessary boundaries to contextualize the internal interactions of the organization and, is represented by the amplifier and attenuator arrows (Hoverstadt, 2020; Lowe et al., 2020). Thus, in Figure 2b, $V_O < < V_E$ means that variety at the level of Operations (or S1) is always less than the variety in the Environment. Similarly, $V_M < < V_O$, indicates that variety is less at Management (S3, S4, S5) than at Operations (S1) since the information is streamlined through the coordinating mechanisms (S2). Attenuator arrows denote processes that select aspects of the system feature that are relevant and filter out less relevant information (Ramírez-Gutiérrez et al., 2021). Stakeholder consultation is an example of carefully designed attenuators that are used to identify relevance and define system boundaries between E and O, while the amplifier arrow symbolizes components that are strategically positioned by M in their environment, E (Ramírez-Gutiérrez et al., 2021; Sydelko et al., 2024). For the purpose of simplification, the attenuator and amplifier arrows are simplified as thick arrows in Figure 2c because the emphasis is laid on unpacking Systems 1 to 5.

2.4.2 Embedding the Viable Systems Model within the TAFS-WCA initiative structure

In the present study, the Full Proposal document of TAFS-WCA elaborates its scope in terms of (i) Priority setting, context and Theory of Change, (ii) Work Packages, and (iii) the Monitoring Evaluation Learning Impact Assessment (MELIA) plan (CGIAR, 2021). Following Jackson's (2003) explanation that organizational complexity can be unfolded along different dimensions, the TAFS-WCA Initiative is examined from a VSM lens where the Initiative refers to the "organisation" (first recursion, Level 0) and is the "system in focus." Given its integrative role and reliance on multiple Work Packages for evidence and input, Work Package 3 forms the primary focus of the analysis. This functional and structural framing is then embedded within a modified Rummler-Brache framework (Brache and Rummler, 1995; Rummler and Brache, 2013) which is a consultancy-driven model for business performance improvement. Here, the framework is used for cross-level alignment of the goals, processes and capability performance of WP3 to ensure viability within the Initiative.

3 Results

3.1 The Viable System Model in sustainability practice: organizational, governance and environmental applications

The Viable System Model (VSM), conceptualized by Stafford Beer, offers a cybernetic framework for understanding and learning about the application of management science methodologies from corporate viability and sustainability (Cardoso Castro, 2019; Gallego-García et al., 2022; Martínez-Lozada and Espinosa, 2022) to complex real-world systems sustainability (Espejo and Schwaninger, 2015; Espinosa et al., 2008; Paucar-Caceres and Espinosa, 2011). Broadly, its application falls either under organizational diagnostics or organizational design to support distributed decision-making processes. The VSM has been extensively utilized for organizational diagnostics, enabling the assessment of internal viability, systemic cohesion, and holistic flexibility (Adham et al., 2025; Awuzie and McDermott, 2017; Espejo and Schwaninger, 2015; Espinosa et al., 2023; Iandolo et al., 2021; Schwaninger and Scheef, 2016; Tong et al., 2022). Other studies have demonstrated its efficacy in identifying dysfunction within management structures, communication channels, and mechanisms that impede sustainable performance (Liboni et al., 2023; Štrukelj et al., 2021) and in building autonomous multi-agency capabilities that strengthen systemic responsiveness and resilience (Ambriz et al., 2024; Fattoum, 2024; Fattoum et al., 2024). The VSM has also been used to design core organizational capabilities to integrate local and national sustainability goals as a methodology to support cross-scale self-transformation (Espinosa, 2015). Sen and Ongsakul (2018) underscore the significance of the VSM in urban sustainability by applying it to the design of climate-proof finance mechanisms, demonstrating how the S3 function of the VSM is operationalized. On the global sustainability scale, Sankaran et al. (2020) advocated for a viable governance structure that aligns megaprojects with the United Nations Sustainable Development Goals to enable integrated and adaptive management.

In the field of management and governance, the VSM is applied in areas where distributed organizational intelligence is key for viability. Espejo (2024) examined the long-standing "Westphalian dilemma" and called for new governance models informed by cybernetic principles to reconcile sovereignty, complexity and global coordination. Thus, the VSM's application in contemporary research and practice (Tong et al., 2018; Vahidi et al., 2019b) are diverse, spanning governance, community engagement, higher education, technological innovation and geopolitical economics (Boucetta et al., 2021; Martínez-Lozada, 2019; Maulén de los Reyes, 2022; Türke, 2006). This implies that the scope of VSM has moved beyond the corporate world focused on organizational knowledge competencies (Al-Raqadi et al., 2017; Clemens, 2009; Vik et al., 2022) to policy, and transdisciplinary research and practice (Adham et al., 2016; Espinosa et al., 2011; Sankaran et al., 2020). This shift requires a new perspective that emphasizes heuristics, control, and feedback responses to address complex problems coherently, rather than relying only on traditional optimization approaches suited to mechanistic problems (Singh et al., 2023; Tong et al., 2018).

In industrial contexts, the VSM can evaluate smart systems with stakeholders' inputs (Chang et al., 2023), industrial sustainability supply chain (Perko et al., 2025), global e-commerce ecosystems

(Dutta, 2023; Solano García et al., 2025), sustainable industrial processes for electric vehicles (Boucetta et al., 2021), eco-innovation in the manufacturing industries (Al-Raqadi et al., 2015; Hernández et al., 2024), energy management (Kouloura et al., 2008) and the application of ISO standards (Panagiotakopoulos et al., 2015). In the health sector, Vik et al. (2022) used the VSM to identify complex issues in the handling of orthopedic patients while Akmal et al. (2023) identified elements that could hinder cohesion in health reform plans. Viewed in this way, the VSM's recursive nature facilitates systemic learning in health systems optimization (Paine et al., 2025; Yahner et al., 2022). The VSM has been adopted in higher education to enhance sustainability governance, curriculum alignment, and stakeholder integration. Mahamed Ismail et al. (2015) applied the VSM to identify domains of research leadership and knowledge sharing. The model's recursive and adaptive nature allows institutions to support distributed decision-making and manage educational, research, and societal functions while responding to organizational sustainability imperatives (Rezk and Gamal, 2019).

Within environmental sustainability contexts, the VSM has been successful in developing the self-organization skills of members of an Irish eco-community as an enabler for community governance and learning process (Espinosa et al., 2011; Espinosa and Walker, 2013). Clemens (2025) combines the VSM with a global Nature-supporting framework to interpret the governance of human-elephant conflict. Alves and Schwaninger (2025) extend the VSM into water resource governance in a hydrographic region in Brazil to reframe water systems management regimes. Thus, in environmental sustainability, the VSM's application has wide applications ranging from restoring ecological balance planning through transdisciplinary and systemic approaches (Schwaninger, 2018) to territorial sustainability studies, particularly in managing community resources, local governance, and multi-stakeholder initiatives (Cardoso Castro et al., 2024; Espinosa and Duque, 2018; Sánchez-García et al., 2019). Its capacity to delineate roles, responsibilities, and systemic boundaries makes it suitable for designing participatory governance models (Espinosa and Martínez-Lozada, 2025), fisheries policy development (Alves et al., 2021), and effective VSM diagnosis supportive of ISO 26000 implementation (Panagiotakopoulos et al., 2016). Tavella and Papadopoulos (2017) provide significant evidence of the VSM's use in community contexts by demonstrating its application to leverage the outcomes of stakeholder engagement processes within a Danish non-profit food cooperative, thereby highlighting the model's relevance for supporting third-sector organizations. Núñez-Ríos et al. (2020) combined the VSM, network analysis and urban agriculture literature to address the problem of the practical organization of relationships among local actors conducive to promoting food self-sufficiency. Causal modeling of the holistic dynamics of integral sustainability in the agri-food system offers a systems-oriented approach that is directly relevant in understanding how viable governance structures can empower local urban food system transformation (Leon-Romero et al., 2024).

However, critiques have emerged regarding the model's abstraction level, which may overlook power asymmetries, informal networks, and cultural dynamics critical to sustainability transitions (Espinosa and Duque, 2018; Tavella and Papadopoulos, 2017). Tavella and Franco (2015) proposed complementary approaches or extensions to VSM for incorporating these nuances. VSM practitioners must remain cognizant of its limitations and contextual interpretations (Harwood, 2019; Lowe et al., 2020). Hence, when explored with

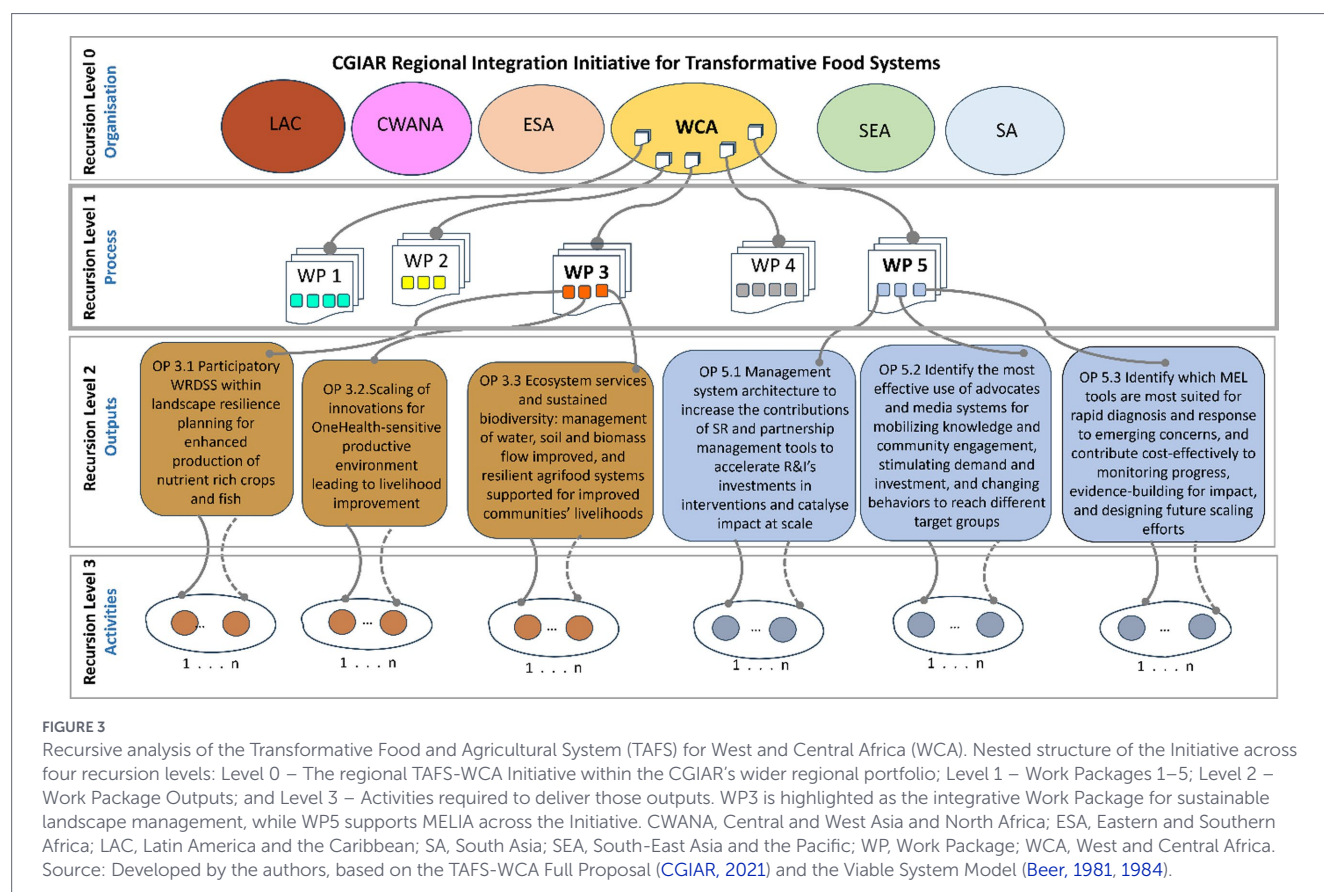
complementary methodologies to address the complexity of networked organizations (Espejo, 2021), context-specific nuances (Panagiotidis et al., 2023), and stakeholder dynamics (Schwaninger, 2019), the VSM offers critical learning opportunities about complex recursive systems. For instance, (Núñez-Ríos et al., 2023) applied partial least squares path modeling (PLS-PM), social network analysis (SNA) and systemic approach tools to incentivize sustainable performance in small- and medium-sized tourism by strengthening inner relations to adapt to a complex environment (Núñez-Ríos and Sánchez-García, 2024). Leonard (2008) demonstrated the utility of the VSM both as a design template and discursive framework for developing multiscale adaptive community structures in response to climate-induced displacement while acknowledging the need for complementary participatory processes, such as Team Syntegrity, to address the socio-political and cultural dimensions of sustainability transitions.

The reviewed literature therefore positions the VSM as a useful framework for examining coordination, feedback and learning in complex sustainability initiatives operating across nested organizational levels, and provides the basis for applying it to TAFS-WCA as a co-design-stage framework for analyzing Work Package interdependencies, outputs and program-level governance.

3.2 Relevance of the Viable System Model for the TAFS-WCA initiative

One of the main contributions of the present work is to explain why the TAFS-WCA can be analyzed as a complex organizational system for designing and coordinating sustainable landscape management within agri-food system transformation in WCA. The methodology describes the objective of the Initiative, its Work Packages, and the components of the MELIA Plan. Then, definitions and theories originating from the fields of systems thinking and the viable systems approach (VSA) are explored. Systems thinking emerged as a transdisciplinary approach to the study of 'systems' of all types (Ramírez-Gutiérrez et al., 2021). It defined a 'system' as a set of interconnected components that share a collective purpose, more than the sum of the individual parts, and develop emergent properties that distinguish them as a whole. In seeking to draw a comparison with the Initiative, TAFS-WCA is viewed as an organizational system.

The purpose is, first, to understand feedback relationships between each project component, namely each Work Package and its Outputs, and the dynamics created when all the WPs are considered together to assess whether the strategically intended outcomes are being met during MELIA exercises. Secondly, the analysis examines whether the Initiative's design contains the organizational conditions needed to support self-organization and adaptation as it implements transdisciplinary research, responds to changing contexts, and seeks to generate innovation within its three-year measurable impact period. Changing contexts here refer to the challenges that emerge during the co-production of outputs generated across the five WPs, despite which the Initiative should remain viable. The systems approach is an important characteristic of project-driven organizations under OneCGIAR and its System Framework (Mayne and Johnson, 2015). In the context of this paper, the Full Proposal document (CGIAR, 2021) indicates that the MELIA Plan of the TAFS-WCA Initiative essentially ensures cross-sectoral and cumulative impacts across the five WPs.



The TAFS-WCA Initiative can be described as having properties of (i) being complex since it involves multiple processes with numerous interrelated components which arise from the interactions between various elements, including people, nested operations, technology, and the external environment. (ii) being governed by feedback mechanisms that need to be characterized to understand the network of information linkages across the WPs for the timely delivery outputs as innovation bundles, (iii) self-regulation structures embedded in the organizational design of the Initiative that need to be represented and sensed across the project hierarchies to monitor performance, detect discrepancies and take corrective actions (iv) adaptability to understand whether objectives are being delivered in a flexible and sustained manner despite the influence of internal and/or external uncertainties and along with emerging opportunities. Thus, the VSM model is applied to the organizational structures of the Initiative to gain vital information about its functioning and ensure its viability. To do this, the Initiative is viewed as a network of nested systems (Figure 3), organized as semi-autonomous systems capable of self-organization in response to changing contexts.

In Figure 3, Recursion Level 0 stands for the TAFS-WCA project as one of the various other Initiatives. The CGIAR Full Proposal dedicates a section to illustrate a set of Theory of Change diagrams (Appendix 1) for the TAFS-WCA Initiative, explaining its intended outcomes, impact, and interrelationships with the relevant targets of the United Nations Sustainable Development Goals. The Recursion Level 1, designated as ‘the system in focus’, refers to the process used to develop the nested system as Work Packages in the Full Document

Proposal. Then, each WP has a nested system for its corresponding Outputs (Recursion Level 2). Finally, each Output has a nested system of Activities (Recursion Level 3). The organization of the nested layers at Level 3 can be further broken down to create a Level 4 recursion to describe the Tasks linked to each Activity. However, for the present work, emphasis is laid on WP3 in the conceptual Viable System Model (VSM).

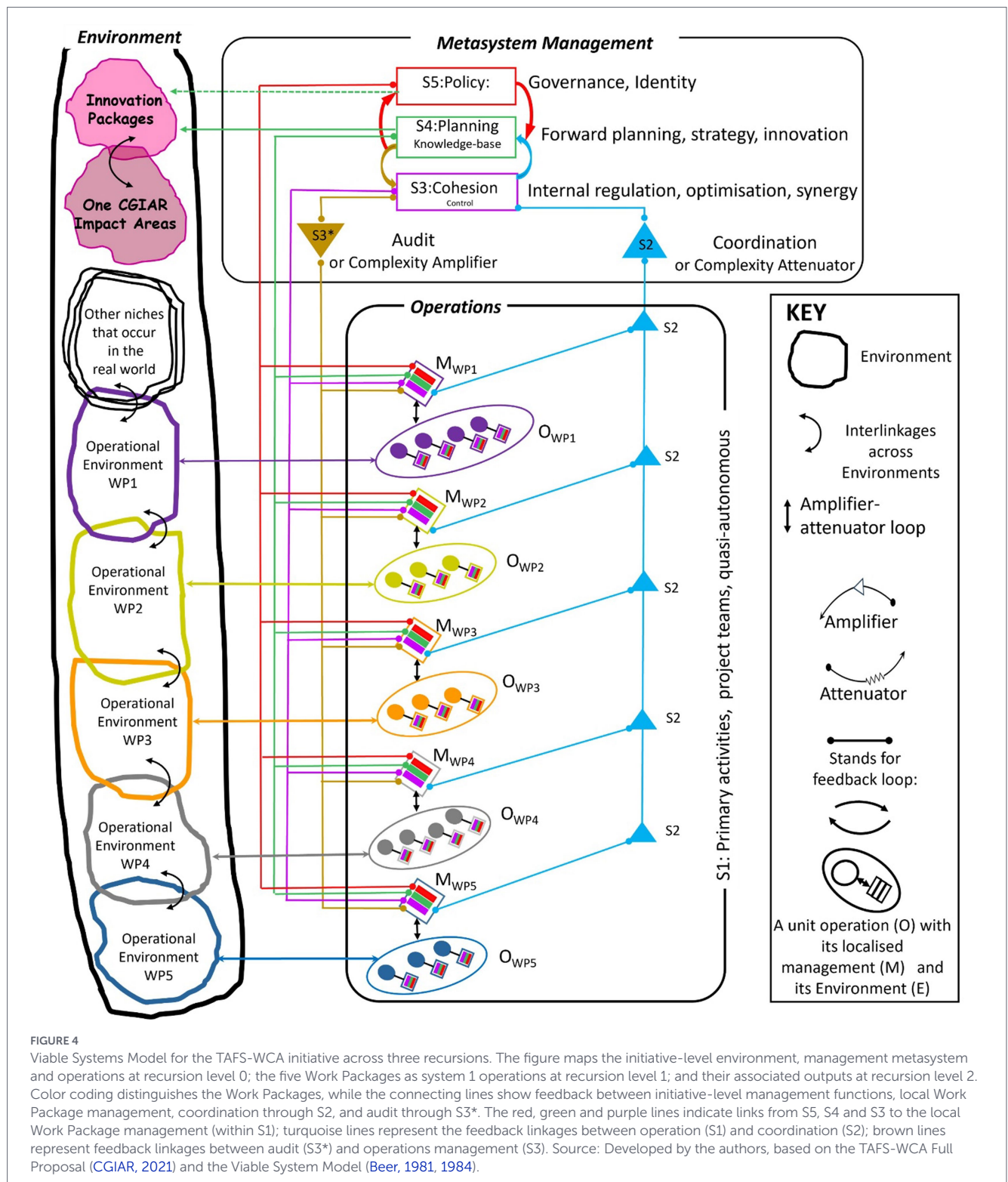
3.3 Modeling the TAFS-WCA initiative as a Viable System Model

3.3.1 Situating Work Package 3 as an S1 operation of the VSM at recursion level 1

Figure 4 presents the viable system analysis for implementing the TAFS-WCA Initiative, in which the five Work Packages constitute the System 1 operations. While all Work Packages are represented as System 1 units, Work Package 3 is selected as the primary focus for detailed analysis because of its integrative role in developing the sustainable landscape management plans and the WRDSS.

3.3.2 System identification, operations, and coordination

Table 1 describes System identification in the TAFS-WCA Initiative when viewed as a VSM. The features are defined from the work of Jackson (2003). System 1 (Operations) and System 2 (Coordination) are described in Table 2.



3.3.3 Interrelationships between the monitoring, evaluation learning and impact assessment (MELIA) plan at S2 (coordination), and S3* (audit) and the management components (S3, S4 and S5)

The reflective component is designed to support knowledge enhancement for the results-oriented Initiative Management Hub (IMH). At the inception phase, the IMH reviews the ToC (Appendix 1), agrees on existing and emerging causal links to

longer-term impact pathways, and validates the Results Framework (RF) with stakeholders in each selected location. Baseline data provide reference values for RF indicators across actors, such as smallholder farmers, youth and women, digital and technology service providers, input dealers, partners, and other stakeholders. Activity-based monitoring, work plans, and Implementation and Progress Reports (IPRs) are then intended to support real-time progress tracking through an automated web-based MEL system, interoperable with the OneCGIAR system. Quarterly IPRs support learning and stage-gating decisions by

TABLE 1 System identification to situate levels of recursion.

Feature (Jackson, 2003)	Description
Identify the purpose(s) to be pursued	Using an appropriate participatory approach The CGIAR has projects in various global geographical regions that all aim to achieve Impact in five areas according to global sustainable targets: (i) Nutrition, health, & food security; (ii) Poverty reduction, livelihoods, & jobs; (iii) Gender, youth, & social inclusion, (iv) Climate adaptation & mitigation, and (v) Environmental health & biodiversity. The Full Proposal Theory of Change (Appendix 1a) for TAFS-WCA documents the context, the country priorities, and three measurable (End of Initiative) outcomes (CGIAR, 2021). Lessons from previous collaborative projects in the WCA, situational analyses and stakeholder consultations have been conducted in different country sites (Atampugre et al., 2021)
Determine the relevant system for achieving the purpose(s)	This refers to the 'system in focus' and I referred to as the Recursion level 1 To achieve the overarching objectives, the Initiative Design Team has developed five Work Packages (Appendix 1). The present work emphasizes WP3 (Appendix 1b). WP 3 has to deliver a sustainable land and water resources decision system and One Health-sensitive bundles that promote gender empowerment and technology use. Other WPs (WP 1, WP2, WP4, WP5) also occur at Level 1 as different System 1 components. Different institutions lead each WP.
Specify the system of which the 'system in focus' is a part.	This is at recursion level 0 and refers to the wider system environments. WP 3 is nested in the TAFS Regional Integrated Initiative for West and Central Africa. The International Water Management Institute (Ghana Office) is responsible for bundling innovations at the landscape level, applying citizen science for healthy environments, and mitigating conflicts. Other institutions are also involved in the delivery of other Work Package deliverables: • International Institute of Tropical Agriculture (IITA) and AfricaRice - sustainable production intensification and access to climate-resilient varieties of grain, legumes and clonal crops • Centro Internacional de la Papa (CIP) for its competencies in biofortified food staples • The Alliance of Bioversity and International Centre for Tropical Agriculture (CIAT) in Climate Smart Agriculture through the Climate Change Agriculture and Food Security (CCAFS) • WorldFish for diversified and healthy production systems • International Livestock Research Institute (ILRI) for support to mixed crop-livestock production systems in the region
Specify the viable parts of System 1 of the 'system in focus' (The purpose is to 'unfold complexity')	These parts produce the 'system in focus', and they occur at recursion level 2. WP1, WP2, WP3, WP4 and WP5 are the parts that produce the TAFS-WCA Initiative.

helping the IMH and stakeholders assess ideas, technologies, and additional innovations beyond the Innovation Basket. Participatory MEL, outcome case studies, mid-term review and external evaluation further support reflection on the relevance, effectiveness, efficiency and sustainability of the change processes.

The Impact Assessment (IA) component is intended to test the underlying assumptions of the ToC, contribute to Innovations' scaling readiness, and assess progress toward expected outcomes. It also provides the basis for examining how Scaling Readiness (SR) frameworks can be validated across contexts and used as planning, scaling, and impact platforms.

From a viable systems perspective, WP 3's interdependencies with other WPs should be reflected in the MELIA plan so that coordination, learning and audit functions can support integrated delivery and effective operational management through S3 (Figure 5) rather than siloed reporting. For instance, the development and roll-out of the WRDSS depends on information on water availability, quality, water risk/scarcity, and water security, as well as water policies and institutions from regional to local scales. It is linked to WP2 and supports the sustainable and equitable scaling of the innovations proposed by WP1 and WP4. WP3 also requires collaboration with relevant global Initiative and Design Teams (IDTs), including those focused on agroecology, policy and strategies, Climber, Aquatic systems, Plant Health Innovation and Nature-positive agriculture. In this way, the WRDSS can connect the Innovation Package and Scaling Readiness Plan to investment decisions and bundled innovations, helping

landscape-level interventions contribute to more productive, healthier and resilient agroecological systems.

3.3.4 The management components of Work Package 3

3.3.4.1 Study system 3 (operations management) - Work Package 3

The purpose of S3 is to maintain cohesion and viability during the Initiative's full duration. At the System 1 level, each WP has a local management function, including M_{WP3} , which should have sufficient autonomy to facilitate information exchange with Initiative-level S3 function as illustrated in Figure 6.

At this stage, the role of the WP3 leadership is crucial in ensuring the performance of the System 1 components, which hereby are Outputs 3.1, 3.2 and 3.3, respectively:

- Setting up of a participatory water and land resources decision support system (WRDSS) aimed at strengthening landscape resilience planning for enhanced production of nutrient-rich crops and fish (OP 3.1)
- Validation of innovations as One Health-sensitive and scaled to contribute to a healthy and productive environment for livelihood improvement (OP 3.2)
- Identification of ways in which ecosystem services/functions and biodiversity can be sustained, management of water, soil and

TABLE 2 Viable System Model diagnosis of TAFS-WCA initiative, the 'system in focus' to model System 1 (Operations) and System 2 (coordination).

System feature	Description
Study System 1 of the system in focus - Operations	
Each part of System1 consists of its environment, operations and localized management	System 1 consists of WP 1, WP 2, WP 3, WP 4 and WP5. Each of these WPs has its environment: the institutions, geographical context, research sites, external partnerships and stakeholder settings. For instance, the operational components in WP 3 aim to enable 100 rural communities to develop informed and inclusive land and water development plans based on One-Health principles and hold dialogs to address gender inequalities in resource access and management structures. The International Water Management Institute in Ghana is responsible for the localized management (Work Package level management) of WP3 across TAFS-WCA. The nature of WP3 is transdisciplinary, as it aims to generate bundles of innovations from WP 1 and WP 3 outputs and to ensure that the critical and gendered dimensions of technology use are addressed (WP4).
Each part of System1 can be viable in its own right	Each WP has been designed to be autonomous even if there are interdependencies with other WPs. For instance, each WP has a dedicated Theory of Change that explains the intended outputs and activities, a set of research questions (Appendix 2) that will generate the evidence base, causal assumptions, and key risks due to interdependencies from other partners/WPs to scale impact. The Theory of Change for WP 3 is shown in Appendix 1b .
Understand the constraints imposed upon the parts of System 1 by higher management	At the co-design phase, the intent is to understand that higher management, that is, System 3, 4 and 5 in a VSM, will impose constraints on the parts of System 1 (that is, each of the WPs) to ensure coordination, alignment with organizational goals, and overall viability. These constraints occur as requests for adequate feedback mechanisms and information flow help create a cohesive and efficient organization capable of adapting to its environment. System constraints here are not intended to be negative. Rather, the implication refers to accountability-based monitoring, evaluation and learning.
Determine how accountability is exercised for each part and what performance indicators are used.	This should be achieved by having regular feedback meetings with demand, innovation, and scaling partners, (ii) other WPs, and (iii) other global Initiatives. For instance, key aspects to be considered for WP 3 coordination would be linkages to innovation bundles and providing data from each WP 3 output to feed the Scaling readiness plan in WP 5.
Study System 2 of the system in focus - Coordination	
List possible sources of disturbance or conflict in the organization	Given the inherently complex nature of the TAFS-WCA Initiative, a coordination mechanism is required to ensure the integration of outputs in WP 3 and information feedback to the MELIA Plan. It involves monitoring, modifying and regulating the various nested subsystems, i.e., Outputs and Activities from other WPs. Disturbances within System 2 (Coordination) can arise from various sources, such as different mandates for different collaborating partners, potentially affecting the Initiative's ability to adapt and maintain viability (Hajjar et al., 2020 ; Kolodny-Goetz et al., 2021)
Identify the various System 2 elements that are needed to ensure harmonization and coordination	System 2 (Coordination), in TAFS-WCA, consists of the Reflective-based Monitoring, Evaluation and Learning (MEL) and the Impact Assessment components.
Inquire how System 2 is perceived in the organization, i.e., as antagonistic or facilitating.	During the co-production phase of TAFS-WCA, systemic learning ought to be promoted among collaborating partners to facilitate the emergence of intended outcomes such as bundles of innovations and sustainable landscape management plans, from the outputs across all WPs. The reflective-based MEL acts as a platform for communication and negotiation of intended outcomes.

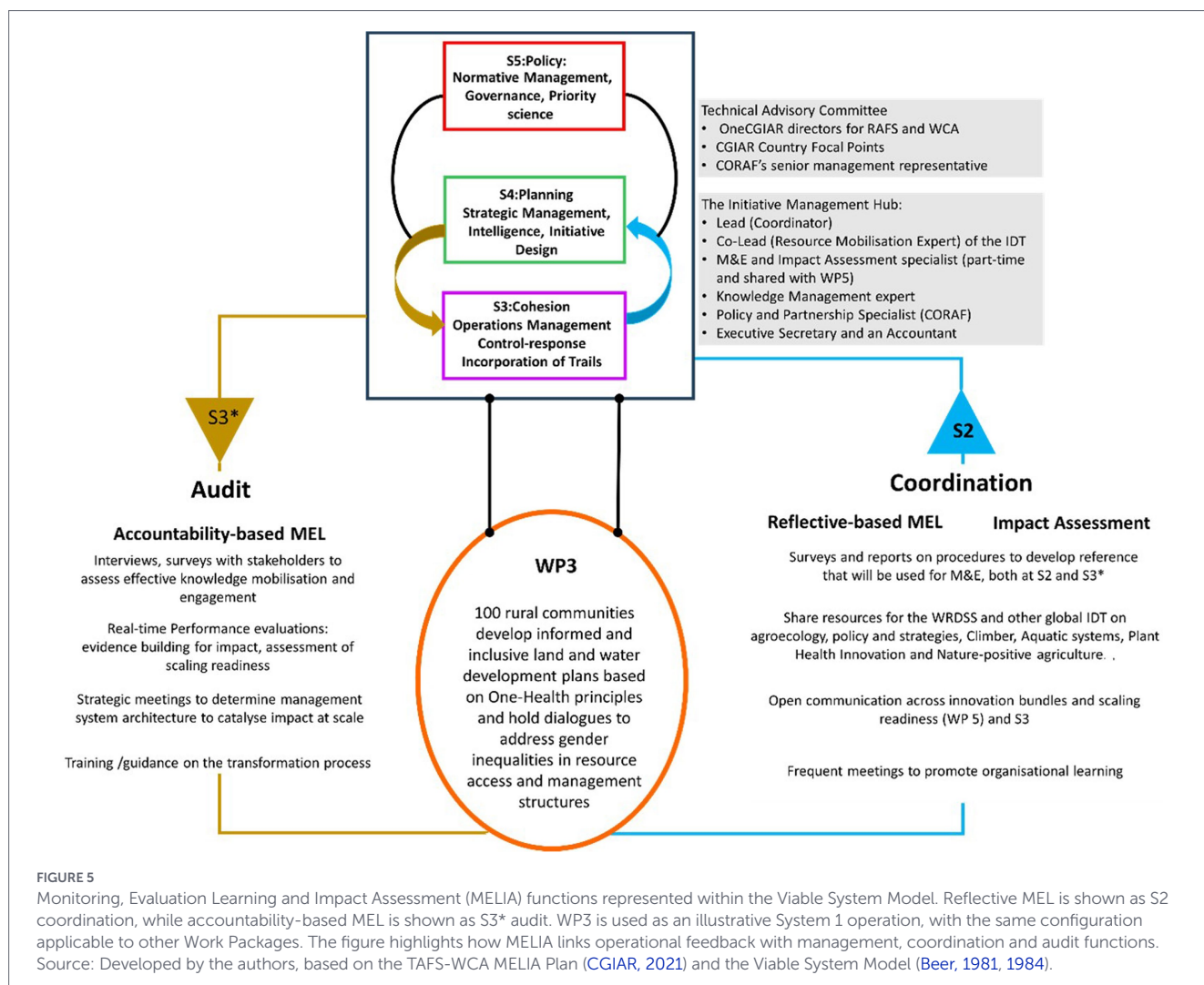
biomass flow improved, and resilient agri-food systems supported for improved communities' livelihoods (OP 3.3)

System 3 seeks to translate the WP3 strategic planning (S4) and policy direction (S5) into successful operations (S1) through alignment between management actions and operational feedback. In WP3, this includes resource mobilization, knowledge management and feedback from the MELIA components, namely S2 and S3*. At this stage, S3 helps identify which accountability-based MEL, as a form of audit (S3*), should be prioritized by making enquiries to understand the progress achieved in System 1 components. These enquiries are made by streamlining input from S2 (Reflective-based MEL and Impact Assessment) and help assess whether MELIA activities are supporting the achievement of WP3's purpose. The simplified VSM-Rummmler-Brache diagnostic framework in [Table 3](#) summarizes

the main alignment questions, while the full set of guiding questions is provided in [Appendix 5](#).

3.3.4.2 Study system 4 (strategic planning management) - Work Package 3

An essential feature of S4 in Work Package 3 is to consider the intended impact of the Outputs and their corresponding Activities within the Initiative's three-year measurable time frame and to evaluate whether the capabilities developed can support adaptation to the future. The role of System 4, therefore, ought to include an intelligence component to detect whether innovation bundles are created systemically in relation to emerging risks, opportunities and external conditions. Key questions include whether S4 provides a hub for bringing



together internal and external information, whether it creates an ‘environment for decision’, and whether it adequately processes, filters and distributes relevant information for strategic adaptation.

The S4-related diagnostic questions summarized in Table 3, and expanded in Appendix 5, can be used to examine how WP3 leadership evaluates, responds to and exchanges such information with the wider Initiative-level management system.

3.3.4.3 Study system 5 (management) - Work Package 3

System 5 establishes the identity, priorities and purposes of WP3. The policy-making function of System 5, herein including the role of the International Water Management Institute, must express and represent the priority science of the TAFS-WCA Initiative. The objectives are determined by considering the state of the TAFS-WCA food system environment and the opportunities and threats that exist. Proper management of this step in the VSM transformative methodology is expected to reduce environmental variety, i.e., external complexity, faced by food systems by helping determine (i) which aspects of the Environment, E, are relevant to the Initiative, (ii) the type of knowledge/evidence base that needs to be deployed, and (iii) whether the operations management has been designed to adapt to transformative processes. To this end, System 5 in WP3 is organised to

examine how purpose in terms of its Theory of Change is defined and maintained (Table 3).

The ultimate purpose of the VSM is to improve performance through its organizational functions. Appendix 5 explains the fuller version of the nine variables that represent management’s performance improvement levers within an adapted Rummler-Brache Nine Box Model (Rummler and Brache, 2012) that unpacks the connection between dynamic capabilities and organizational performance and can be viewed as a preliminary outline to develop a learning framework across the nested hierarchies (Initiative-WP-Output). For ease of identifying the different nested organizational levels, a summary of the VSM functions for the TAFS-WCA Initiative is provided in Table 4.

4 Discussion

4.1 Program viability and feedback architecture for sustainable food system transformation

This study examines how the Transforming Agri-Food Systems in West and Central Africa (TAFS-WCA) Initiative can be

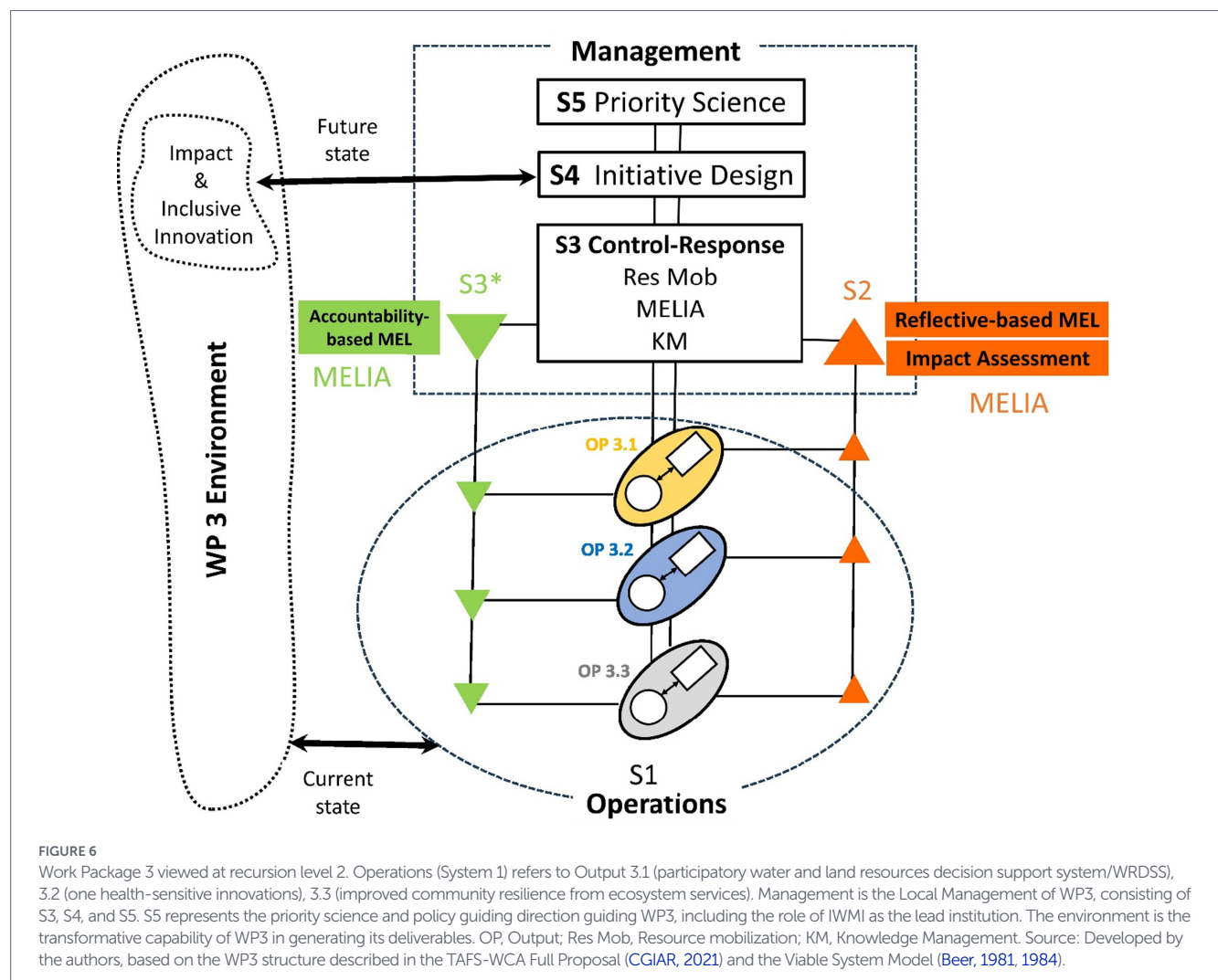


TABLE 3 Simplified VSM-Rummler-Brache diagnostic framework for interpreting Work Package 3 alignment.

Viable System Model function	Rummler-Brache focus	Main diagnostic question	Relevance to Work Package (WP) 3
S5 Policy/Identity	Goals	Are the purpose, priorities and intended outcomes clear?	Helps clarify how WP3's landscape management role is aligned with the Initiative's Theory of Change and priority science
S4 Strategic Intelligence	Goals	Is the system scanning future risks, opportunities and external change?	Draws attention to how WP3 responds to changing landscape, water, food system and governance conditions
S3 Operations management	Goals	Are current operations aligned with strategic priorities?	Helps clarify how WP3 leadership aligns resources, outputs and decision-making across its outputs
S5 Policy/Identity	Process	Are roles and boundaries clearly defined?	Supports reflection on whether WP3's mandate, partner roles and responsibilities are clearly positioned within the wider Initiative
S4 Strategic Intelligence	Process	Are information flows supporting adaptation?	Highlights how evidence from other WPs and the external environment can inform WP3 planning and adaptation
S3 Operations management	Process	Are coordination and feedback mechanisms working?	Draws attention to how MELIA, knowledge management and resource mobilization can support WP3 delivery
S5 Policy/Identity	Capability	Are values, legitimacy and accountability sufficient?	Supports reflection on how WP3 maintains coherence with OneHealth, inclusion and sustainable food system transformation goal
S4 Strategic Intelligence	Capability	Is there enough learning and foresight capacity?	Signals the need for WP3 to build the learning and foresight capacity to anticipate risks and adapt its innovation pathways
S3 Operations management	Capability	Are resources and implementation capacity sufficient?	Highlights WP3's management capacities to deliver the participatory Water Resources Decision Support System, OneHealth sensitive innovations and ecosystem services outputs?

TABLE 4 Summary of the components of the five VSM functions at three nested organizational levels.

VSM functions	At recursion level 1 (What does the Initiative constitute of?)
Operations (S1)	=WP1, WP2, WP 3, WP 4, WP5
Coordination (S2)	=Reflective-based MEL and Impact Assessment
Operational Management (S3)	= Control-response process by incorporation of trials through Resource Mobilization and Knowledge Management
Audit (S3*)	=Accountability-based MEL
Strategic Management & Planning (S4)	=Initiative Design and Innovation Management Hub
Policy/Governance Management (S5)	=Priority Science at CGIAR TAC
VSM functions	At recursion level 2, what does WP3 constitute?
Operations (S1)	=OP 3.1, OP 3.2, OP 3.3
Coordination (S2)	=Reflective-based MEL and Impact Assessment for WP3: each OP responds to impact assessment (<i>ex-ante</i> and <i>ex-post</i>) and uses the learning-based framework of M&E to improve performance
Operational Management (S3)	=Control-response process by adhering and responding to trails set up to meet WP3 objectives
Audit (S3*)	=Accountability-based MEL for WP 3: the readiness of each OP to contribute to the Initiative's baseline survey using digital and automated M&E tools
Strategic Management & Planning (S4)	=Initiative Design and Innovation Management Hub: (i) validate transformative processes to deploy the WRDSS, (ii) link up and collaborate with relevant global IDTs, especially on agroecology, policy and strategies, Climber, Aquatic systems, Plant Health Innovation and Nature-positive agriculture
Policy/Governance Management (S5)	=Priority Science: each OP respond to ways inclusive landscape management and water resources can be applied to enhance the use and scaling of innovations toward a One Health-sensitive environment, improved productivity and livelihoods in WCA
VSM functions	At recursion level 3, what do the outputs of WP3 constitute?
Operations (S1)	= OP 3.1.1, OP 3.1.2, OP 3.1.3, OP 3.2.1, OP 3.2.2, OP 3.3.1, OP 3.3.2, OP 3.3.3
Coordination (S2)	= Reflective-based MEL and Impact Assessment: Each activity responds to impact assessment (<i>ex-ante</i> and <i>ex-post</i>) and uses the learning-based framework of M&E to improve performance for its corresponding OP
Operational Management (S3)	=Control-response process by adhering and responding to trails set-up to meet the corresponding OP's objectives
Audit (S3*)	=Accountability-based MEL for WP 3
Strategic Management & Planning (S4)	=Initiative Design and Innovation Management Hub: Each Activity ought to be aligned with the deliverables of the respective OPs.
Policy/Governance Management (S5)	=Priority Science: Each Activity ought to be aligned with their specific research questions, associated scientific methods and outputs

understood as a viable organizational system during its co-design phase, and to analyze how Work Package 3 (WP3) depends on and contributes to system-wide coordination, learning and performance. The purpose was not to evaluate implementation, but rather to examine the Initiative's proposed structures by using the VSM to clarify interdependencies and the organizational functions required for coherent delivery across scales. Several key concepts emerge from this process. First, the VSM analysis uses the structure of the Initiative which is based on the CGIAR organizational model to make explicit the functional requirements for organizational viability namely: Operations (S1), Coordination (S2), Operational Management and Audit (S3 and S3*), Strategic Intelligence (S4) and Governance (S5), and how these must interact across the nested organizational levels to maintain stability while enabling adaptation. Applying this framing to the TAFS-WCA Initiative

clarifies the vertical and horizontal interdependencies that shape how Work Packages relate to one another, and where coordination and learning processes must be consolidated to avoid fragmentation.

Second, by matching WP3's expected deliverables with the Outputs from other WPs and using the Theory of Change as a guiding tool, the analysis demonstrates how WP3's role is structurally dependent on evidence, inputs and collaborative processes that originate elsewhere in the Initiative. Such interrogation helps make these interrelationships visible, showing where coordination mechanisms (S2), operational management (S3) and strategic oversight (S4, S5) are essential for translating distributed evidence into integrated sustainable landscape management plans and a functional Water Decision Support System. This highlights WP3's centrality as both a beneficiary of systemic alignment and a generator of system-wide adaptive

capacity, because its outputs feed back into the Initiative's Innovation Platforms and MELIA processes.

Third, the analysis reveals important emergent properties. Feedback coherence, particularly through the MELIA structure, emerges as a critical condition for viability. Then, reflective learning acts as an attenuator filtering complex information from multiple WPs into actionable insights for S3, S4 and S5, while accountability processes (S3*) strengthen and translate strategic decisions back into operational adjustments. An example of this amplification would be for S3, S4 and S5 functions to ensure that gender transformation aspects are streamlined across WPs. These interactions underpin the role of MELIA not only as a reporting mechanism but also as a system-level feedback architecture that supports adaptability across recursion levels.

Another practical value of the MELIA structure viewed through the VSM lens is that the analysis identifies where coordination structures may need consolidation, where role (within VSM function) clarity across the nested organizational levels will matter for implementation, and how MELIA mechanisms can be shaped to support learning and accountability. These offer a starting point for strengthening WP3's operational relationships with other WPs and for supporting the Initiative's leadership in anticipating areas where system alignment may require attention. Thus, a subsequent practical step following the conceptual analysis would be to use the VSM functions during the early implementation cycles to assess whether the intended interactions are occurring and to identify adjustments that support coherence across the Initiative.

Such insights are relevant beyond the TAFS-WCA context as complex sustainability initiatives face similar challenges in streamlining distributed evidence generation and coordinating multi-actor and cross-scale decision-making. The VSM analysis aligns with several United Nations Sustainable Development Goals because the Initiative addresses food system transformation, landscape resilience, water resource decision support, One Health-sensitive innovation, and cross-sectoral partnerships. The most direct alignment is therefore with SDG 2 on Zero Hunger, SDG 3 on good health and well-being, SDG 6 on clean water and sanitation, SDG 12 on responsible consumption and production, SDG 13 on climate action, SDG 15 on life on land, and SDG 17 on partnerships for the goals. Rather than treating the SDGs as separate targets, the VSM frames the organizational and feedback conditions through which such interconnected goals can be coordinated within the boundaries set by the Theory of Change of a complex sustainability initiative. Thus, a VSM-based inquiry provides a transferable means to elicit organizational functions and dependencies during co-design, particularly for programs seeking to integrate socio-technical and socio-ecological innovation processes, as this involves aligning multi-lateral and transdisciplinary Communities of Practice. The underlying organizational logic is not domain-specific and may therefore have broad application in sustainability interventions.

However, the practical use of the VSM within the CGIAR-type of initiatives may face adoption barriers. Project managers and Work Package leads may not be familiar with organizational cybernetics, and the terminology and diagrammatic conventions of the VSM may require facilitation prior to their use in planning MELIA processes. Existing MELIA systems may not prioritize reflective diagnosis,

feedback-loop mapping and nested-level analysis. For this reason, the VSM should not be introduced as an additional technical burden, but as a light-touch diagnostic and learning tool that can be integrated into existing reflection workshops, annual planning cycles, MELIA reviews and adaptive management discussions. This would allow the framework to support sense-making and coordination without requiring major redesign of existing MELIA architectures.

Moreover, the practical value of the VSM diagnosis differs across stakeholder groups. For example, for the Initiative's leadership, corresponding broadly to S4 and S5 functions, [Figures 3, 4](#) can support strategic reflection and foresight on how Work Packages (S1) Outputs and Activities are recursively connected and how these respond to external change and program identity. For Work Package leads, corresponding to S3 functions, the diagrams can be used to identify operational dependencies, evidence flows and potential bottlenecks across Work Packages. In WP3, specifically, the diagnosis clarifies which evidence inputs are required from other WPs to develop the landscape management plans and the participatory WRDSS. When the VSM is intended for MELIA officers, [Figure 5](#) provides a structured way to distinguish reflective learning functions from accountability and audit functions. In field-based management and operations settings, these figures could therefore support annual planning workshops, MELIA review meetings, adaptive management discussions and stakeholder reflection processes. Their practical value lies in helping teams translate an abstract systems model into a shared visual language for diagnosing coordination, clarifying responsibilities and tracking whether intended feedback behaviors are occurring during implementation. For donors and program partners, it offers a transparent explanation of how feedback, learning, and accountability can support coherent delivery across a complex, multi-country sustainability initiative.

4.2 Limitations, methodological positioning, and future empirical validation

This section positions the methodological contribution of the study and clarifies the scope for future empirical validation. The analysis is based primarily on proposal-stage and co-design documentation and therefore reflects intended organizational architecture rather than observed organizational behavior during implementation. This scope is consistent with the study's deductive-abductive research design. The deductive component applies the predefined functions of the Viable System Model to the TAFS-WCA Initiative while the abductive component uses the Initiative's structure, ToC, Work Packages, and MELIA arrangements to develop plausible systems explanations of how coordination, accountability, learning and strategic adaptation are expected to operate. This approach is appropriate because the purpose of the study is not to evaluate the program, but to examine whether the proposal-stage architecture contains the organizational functions required for viability, coherence and adaptive management. A further implication is that the VSM diagnosis represents a snapshot of the co-design phase rather than a dynamic assessment of how the Initiative evolves. Future empirical work could apply the same diagnostic categories at successive implementation points to examine how coordination, learning, accountability and strategic adaptation evolve during the implementation period.

Similarly, the use of the Rummler-Brache framework is conceptual rather than empirical. It is used to complement the VSM diagnosis by highlighting performance alignment across goals, processes and capabilities, rather than to measure performance outcomes directly. Future work could therefore empirically test the VSM diagnosis using implementation-stage evidence. The 2024 Annual Technical Report for the Initiative provides a relevant secondary source of evidence for such validation, as it documents progress across the 2022–2024 implementation cycle, including results, knowledge products, innovation scaling, capacity-sharing activities, stakeholder workshops and progress against End-of-Initiative outcomes (CGIAR, 2025a). This could be complemented by the CGIAR's broader MELIA learning evidence, which emphasizes the importance of the ToC and MELIA reporting for adaptive management and decision-making across the CGIAR's portfolios (CGIAR, 2025b). Such evidence could be triangulated with MELIA outputs, interviews with Initiative and Work Package leads, stakeholder reflection workshops and records of adaptive management decisions to assess whether the *ex-ante* diagnosis was enacted in practice and which modifications are required to improve adaptive management in future initiatives. Overall, the analysis demonstrates how cybernetic framing can strengthen the design and future evaluation of large, transdisciplinary sustainability initiatives by clarifying feedback processes and supporting coherent pathways for coordinated innovation from the outset.

5 Conclusion

This study demonstrates how the Viable System Model can be used to examine the organizational structure of a large transdisciplinary food system initiative during its co-design phase. By interpreting the TAFS-WCA Initiative as a nested organizational system, the analysis makes apparent the functions required for coordinated delivery across Work Packages, Outputs and program-level governance. It also clarifies the integrative role of Work Package 3, whose ability to develop sustainable landscape management plans and a participatory water and land resources decision support system depends on evidence flows, coordinated mechanisms and strategic alignment across the wider initiative.

A central contribution of the analysis is the positioning of MELIA as more than a reporting function. When interpreted through the VSM, reflective learning, operational oversight, audit, strategic intelligence and governance form an interconnected feedback architecture that can support adaptation and organizational coherence. The adapted Rummler-Brache framework further translates these functional relationships into questions of goals, processes and capabilities.

The study is intentionally bounded by the co-design phase and does not assess the implementation effectiveness. Its value lies in providing an *ex-ante* diagnostic framework that can guide future empirical inquiry. Applied iteratively during implementation, the framework could help program leaders, Work Package teams and MELIA actors identify coordination gaps, clarify responsibilities and assess whether intended feedback processes are operating in practice. More broadly, the approach offers a transferable method for strengthening the design and adaptive governance of complex sustainability initiatives.

Author contributions

NS-F: Conceptualization, Formal analysis, Investigation, Methodology, Writing – original draft, Writing – review & editing. OC: Funding acquisition, Writing – review & editing. RS: Funding acquisition, Supervision, Writing – review & editing. TM: Conceptualization, Funding acquisition, Methodology, Supervision, Writing – review & editing.

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Conflict of interest

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References

- Achterbergh, J., and Vriens, D. (2011). "Cybernetically sound organizational structures II: Relating de Sitter's design theory to Beer's viable system model", *Kybernetes*, Emerald Group Publishing Ltd., 40, 425–438. doi: 10.1108/03684921111133665/FULL/HTML
- Adham, K. A., Munawar, A., Shihama, M., and Nasir, N. M. (2025). Government support for halal tourism: a viable system model analysis of the Maldives. *J. Islam. Mark.* 17, 1669–1695. doi: 10.1108/JIMA-10-2024-0455/1299397
- Adham, K. A., Sarkam, S. F., Said, M. F., Nasir, N. M., and Kasimin, H. (2016). "Monitoring of policy implementation: convergent mobile and fixed technologies as emergent enablers", *Syst. Pract. Action Res.* 30: 535–551. doi: 10.1007/S11213-016-9406-3
- Akmal, A., Podgorodnichenko, N., Gauld, R., and Stokes, T. (2023). New Zealand Pae Ora healthcare reforms 2022: viable by design? A qualitative study using the viable system model. *Int. J. Health Policy Manag.* 12, 1–13. doi: 10.34172/IJHPM.2023.7906
- Al-Raqadi, A. M. S., Abdul Rahim, A., Masrom, M., and Al-Riyami, B. S. N. (2015). Enhancing transparency and learning sustainability on the perceptions of improving naval ships' support performance. *Int. J. Syst. Assur. Eng. Manag.* 8, 265–289. doi: 10.1007/S13198-015-0383-1
- Al-Raqadi, A. M. S., Abdul Rahim, A., Masrom, M., and Al-Riyami, B. S. N. (2017). Sustainability of knowledge and competencies management on the perceptions of improving ships' upkeep performance. *Int. J. Syst. Assur. Eng. Manag.* 8, 230–246. doi: 10.1007/s13198-015-0382-2
- Alves, J. M., and Schwaninger, M. (2025). Model-based governance: a cybernetic approach to water allocation control. *Environ. Manag.* 75, 3344–3363. doi: 10.1007/S00267-025-02262-7
- Alves, J. M., Rodrigues, W., Vergara, F. E., Souza, F. N., and Terra, L. A. A. (2021). From the black box to the fish farming development policy project: a diagnosis from the viable system model. *Syst. Res. Behav. Sci.* 38, 459–472. doi: 10.1002/SRES.2675
- Ambriz, S., Denny, J. Y., Sánchez-García, J. E., Suarez Ambriz, D., Sánchez-García, J. Y., and Núñez-Ríos, J. E. (2024). An organizational framework for microenterprises to face exogenous shocks: a viable system approach. *Adm. Sci.* 14:315. doi: 10.3390/ADMSCI14120315
- Atampugre, G., Nurse-Bray, M., Masud-All-Kamal, M., and Nyarko, B. K. (2021). Assessing Farm-Households' Vulnerability to Climate Change Risks in Semi-arid Ghana. In: G. M. M. Alam, M. O. Erdiaw-Kwasie, G. J. Nagy and W. Leal Filho (eds.) *Climate Vulnerability and Resilience in the Global South*. Climate Change Management. Springer, Cham. doi: 10.1007/978-3-030-77259-8_27
- Awuzie, B., and McDermott, P. (2017). An abductive approach to qualitative built environment research: a viable system methodological exposé. *Qual. Res. J.* 17, 356–372. doi: 10.1108/QRJ-08-2016-0048
- Barile, S., and Saviano, M. (2018). "Complexity and sustainability in management: insights from a systems perspective", *New Economic Windows*, Springer-Verlag Italia s.r.l., 39–63. doi: 10.1007/978-3-319-61967-5_3/COVER
- Battisti, C. (2018). Unifying the trans-disciplinary arsenal of project management tools in a single logical framework: further suggestion for IUCN project cycle development. *J. Nat. Conserv., Urban & Fischer*, 41, 63–72. doi: 10.1016/J.JNC.2017.11.005
- Beer, S. (1981). *Brain of the Firm: The Managerial Cybernetics of Organization*. 2nd Edn Chichester, West Sussex: J. Wiley.
- Beer, S. (1984). The viable system model: its provenance, development, methodology and pathology. *J. Oper. Res. Soc.* 35, 7–25. doi: 10.1057/jors.1984.2
- Belcher, B., and Halliwell, J. (2021). "Conceptualizing the elements of research impact: towards semantic standards", *Humanities and Social Sciences Communications* 2021 8:1, Palgrave, 8, 1–6. doi: 10.1057/s41599-021-00854-2
- Boucetta, M., Hossain, N. U. I., Jaradat, R., Keating, C., Tazzit, S., and Nagahi, M. (2021). The architecture design of electrical vehicle infrastructure using viable system model approach. *Systems* 9:19. doi: 10.3390/SYSTEMS9010019
- Brache, A. P., and Rummler, G. A. (1995). Invited reaction: performance improvement: a methodology for practitioners. *Hum. Resour. Dev. Q.* 6, 35–38. doi: 10.1002/HRDQ.3920060104
- Cardoso Castro, P. P. (2019). The viable system model as a framework to guide organisational adaptive response in times of instability and change. *Int. J. Organ. Anal.* 27, 289–307. doi: 10.1108/IJOA-01-2018-1334/FULL/XML
- Cardoso Castro, P. P., Vachkova, M., Ravena, N., and Veloso, N. (2024). The one million cisterns programme—a viability assessment of community rainwater management in Brazil. *Front. Sustain.* 5:1401440. doi: 10.3389/fsufs.2024.1401440
- CGIAR (2021). *Transforming AgriFood Systems in West and Central Africa (TAFS-WCA) Full Proposal Accra Ghana*: CGIAR. doi: 10.1108/IJOA-01-2018-1334
- CGIAR (2025a). *Annual Technical Report 2024: CGIAR Research Initiative on Transforming AgriFood Systems in West and Central Africa*. Montpellier: France.
- CGIAR (2025b). *Summary of Learnings on Monitoring, Evaluation, Learning and Impact Assessments (MELIA)*. Rome, Italy.
- Chang, Y., Ming, X., Chen, Z., Zhou, T., Liao, X., and Song, W. (2023). Stakeholder requirement evaluation of smart industrial service ecosystem under Pythagorean fuzzy environment for complex industrial contexts: a case study of renewable energy park. *Adv. Eng. Inform.* 55:101823. doi: 10.1016/J.AEI.2022.101823
- Chronéer, D., and Backlund, F. (2015). A holistic view on learning in project-based organizations. *Project Management Journal*, Wiley-Blackwell 46, 61–74. doi: 10.1002/PMJ.21503
- Clemens, R. (2009). Environmental scanning and scenario planning: a 12 month perspective on applying the viable systems model to developing public sector foresight. *Syst. Pract. Action Res.* 22, 249–274. doi: 10.1007/s11213-009-9127-y
- Clemens, R. (2025). Combining the viable system model and nature futures framework. *Syst. Pract. Action Res.* 38:11. doi: 10.1007/S11213-025-09718-1
- Coccia, F., Rouge, J.-C., and Gitz, V. (2022). "Assessing the impact of 10 years of FTA research: a synthesis of the 5 integrated impact studies" in *Assessing the Impact of 10 Years of FTA Research: A Synthesis of the 5 Integrated Impact Studies* Center for International Forestry Research (CIFOR). doi: 10.17528/CIFOR/008514
- de Groot, B., Leendertse, W., and Arts, J. (2020). "Building adaptive capacity through learning in project-oriented organisations in infrastructure planning", *Urban Planning*, Cogitatio Press, 5, 33–45. doi: 10.17645/UP.V5I1.2523
- de Groot, B., Leendertse, W., and Arts, J. (2022). "Learning across teams in project-oriented organisations: the role of programme management", *Learning Organization*, Emerald Group Holdings Ltd., 29, 6–20. doi: 10.1108/TLO-06-2020-0118/FULL/PDF
- Devine, S. (2005). "The viable systems model applied to a national system of innovation to inform policy development", *Systemic Practice and Action Research*, Springer, 18, 491–517. doi: 10.1007/S10979-005-8485-Y/METRICS
- Dutta, K. (2023). Exploring digital multisided platforms: a systems thinking approach. *Syst. Pract. Action Res.* 36, 851–876. doi: 10.1007/s11213-023-09631-5
- Espejo, R. (2021). The enterprise complexity model: an extension of the viable system model for emerging organizational forms. *Syst. Res. Behav. Sci.* 38, 721–737. doi: 10.1002/SRES.2735
- Espejo, R. (2024). Institutions, nations, enterprises and distributed organisation (the Westphalian dilemma). *Cybernet. Syst.* 55, 137–156. doi: 10.1080/01969722.2022.2095758
- Espejo, R., and Schwaninger, M. (2015). Organizing for sustainability: a cybernetic concept for sustainable renewal. *Kybernetes* 44, 935–954. doi: 10.1108/K-01-2015-0008
- Espinosa, A. (2015). Governance for sustainability: learning from VSM practice. *Kybernetes* 44, 955–969. doi: 10.1108/K-02-2015-0043
- Espinosa, A., and Duque, C. (2018). Complexity management and multi-scale governance: a case study in an Amazonian indigenous association. *Eur. J. Oper. Res.* 268, 1006–1020. doi: 10.1016/J.EJOR.2017.07.049
- Espinosa, A., and Martínez-Lozada, A. C. (2025). The viable system model to support sustainable self-governance in communities: learning from case studies. *Syst. Pract. Action Res.* 38:14. doi: 10.1007/S11213-025-09724-3
- Espinosa, A., and Walker, J. (2013). Complexity management in practice: a viable system model intervention in an Irish eco-community. *Eur. J. Oper. Res.* 225, 118–129. doi: 10.1016/J.EJOR.2012.09.015
- Espinosa, A., Cardoso, P. P., Arcaute, E., and Christensen, K. (2011). Complexity approaches to self-organisation: a case study from an Irish eco-village. *Kybernetes* 40, 536–558. doi: 10.1108/03684921111133737
- Espinosa, A., Harnden, R., and Walker, J. (2008). A complexity approach to sustainability – Stafford Beer revisited. *Eur. J. Oper. Res.* 187, 636–651. doi: 10.1016/J.EJOR.2007.03.023
- Espinosa, A. M. (2023) in *Sustainable Self-Governance in Businesses and Society the Viable System Model in Action*, ed. G. Midgley. 1st ed (Abingdon, Oxon: Routledge).
- Espinosa, A. M., Walker, J., Grover, K., and Vachkova, M. V. (2023). The viability and sustainability approach to support organisational resilience: learning in a recent case study in the health sector. *Syst. Res. Behav. Sci.* 40, 689–700. doi: 10.1002/SRES.2951
- Fattoum, A. (2024). Delegated autonomy in multi-agency viable systems: social and systemic factors during crisis. *Syst. Pract. Action Res.* 37, 739–763. doi: 10.1007/S11213-024-09706-X
- Fattoum, A., Chari, S., and Shaw, D. (2024). Configuring systems to be viable in a crisis: the role of intuitive decision-making. *Eur. J. Oper. Res.* 317, 205–218. doi: 10.1016/J.EJOR.2024.03.034
- Gallego-García, S., Ren, D., Gallego-García, D., Pérez-García, S., and García-García, M. (2022). Dynamic innovation information system (DIIS) for a new management age. *Appl. Sci.* 12:6592. doi: 10.3390/AP12136592
- Gupta, A., Singh, A., Aneja, K., Aggarwal, V., Wadhwa, J., and Abraham, D. (2023). How to write a scoping review? - a comprehensive guide. *Endodontology* 35, 9–14. doi: 10.4103/ENDO.ENDO_123_22
- Hajjar, L., Cook, B. S., Domlyn, A., Ray, K. A., Laird, D., and Wandersman, A. (2020). Readiness and relationships are crucial for coalitions and collaborators: concepts and evaluation tools. *New Dir. Eval.* 2020, 103–122. doi: 10.1002/EV.20399
- Harwood, S. A. (2019). A question of interpretation: the viable system model (VSM). *Eur. J. Oper. Res.* 274, 1198–1201. doi: 10.1016/J.EJOR.2018.10.054
- Heilmann, A., Spaunhorst, R., and Schulz, F. (2022). "Methodology for selecting agile methods in transdisciplinary sustainability projects" in *Handbook of Sustainability Science in the Future* (Cham: Springer), 1–10. doi: 10.1007/978-3-030-68074-9_102-1

- Hernández, B., Aguilar-Fernández, A. D., Strategic, M., Barragán-Hernández, A., and Aguilar-Fernández, M. (2024). Strategic dimensions of eco-innovation adoption in manufacturing SMEs in the context of Mexico City. *Systems* 12:246. doi: 10.3390/SYSTEMS12070246
- Hodgson, A. (2012). "A transdisciplinary world model", *Systems Research and Behavioral Science*, John Wiley & Sons, Ltd, 29:517–526. doi: 10.1002/SRES.2154
- Holzer, J. M., Adamescu, C. M., Cazacu, C., Díaz-Delgado, R., Dick, J., Méndez, P. F., et al. (2019). "Evaluating transdisciplinary science to open research-implementation spaces in European social-ecological systems", *Biological Conservation*, Elsevier, 238:108228. doi: 10.1016/J.BIOCON.2019.108228
- Hoferstadt, P. (2020). "The viable system model," in *Systems Approaches to Making Change: A Practical Guide*, eds. M. Reynolds and S. Holwell. 2nd ed (London: Springer), 89–138.
- Iandolo, F., Vito, P., Loia, F., Fulco, I., and Calabrese, M. (2021). Drilling down the viable system theories in business, management and accounting: a bibliometric review. *Syst. Res. Behav. Sci.* 38, 738–755. doi: 10.1002/sres.2731
- Jackson, M. C. (2003). *Systems Thinking: Creative Holism for Managers*. 1st Edn Chichester, West Sussex: J. Wiley & Sons.
- Kolodny-Goetz, J., Hamm, D. W., Cook, B. S., and Wandersman, A. (2021). The readiness, resilience and recovery tool: an emerging approach to enhance readiness amid disruption. *Glob. Implement. Res. Appl.* 1, 135–146. doi: 10.1007/S43477-021-00011-6
- Kouloura, T. C., Panagiotakopoulos, P. D., and Safigianni, A. S. (2008). A systems approach to corporate sustainability in energy management of industrial units. *IEEE Syst. J.* 2, 442–452. doi: 10.1109/JSYST.2008.2003296
- Lechler, R. C., Lehner, P., Rössli, F., and Huemann, M. (2022). "The project-oriented organisation through the lens of viable systems", Project Leadership and Society, Elsevier, 3:100072. doi: 10.1016/J.PLAS.2022.100072
- Leonard, A. (2008). Integrating sustainability practices using the viable system model. *Syst. Res. Behav. Sci.* 25, 643–654. doi: 10.1002/sres.937
- Leon-Romero, L. P., Zamora-Polo, F., Luque-Sendra, A., Aguilar-Fernández, M., and Francisco-Márquez, M. (2024). Characterisation and causal model of the holistic dynamics of the integral sustainability of the Agri-food system. *PLoS One* 19:e0305743. doi: 10.1371/JOURNAL.PONE.0305743
- Liboni, L. B., Cezarino, L. O., Donaires, O. S., and Zollo, M. (2023). Systems approach in dynamic capabilities. *Syst. Res. Behav. Sci.* 40, 863–875. doi: 10.1002/sres.3204
- Lowe, D., Espinosa, A., and Yearworth, M. (2020). Constitutive rules for guiding the use of the viable system model: reflections on practice. *Eur. J. Oper. Res.* 287, 1014–1035. doi: 10.1016/J.EJOR.2020.05.030
- Mahamed Ismail, N. A., Welch, C., and Xu, M. (2015). Towards a sustainable quality of university research: knowledge sharing. *Knowl. Manag. Res. Pract.* 13, 168–177. doi: 10.1057/KMRP.2013.39
- Martinez-Lozada, A. C. (2019). Facilitating organizational action regarding a co-operative's governance system in a developing country using the viable systems model. *Syst. Res. Behav. Sci.* 36, 538–550. doi: 10.1002/SRES.2569
- Martinez-Lozada, A. C., and Espinosa, A. (2022). Corporate viability and sustainability: a case study in a Mexican corporation. *Syst. Res. Behav. Sci.* 39, 143–158. doi: 10.1002/SRES.2748
- Maulén de los Reyes, D. (2022). Why did cybernetics disappear from Latin America?: an incomplete timeline. *AI Soc.* 37, 1293–1306. doi: 10.1007/s00146-021-01350-6
- Mayne, J., and Johnson, N. (2015). "Using theories of change in the CGIAR Research Program on Agriculture for Nutrition and Health", Evaluation, SAGE Publications Ltd, 21, 407–428. doi: 10.1177/1356389015605198
- McGregor, S. L. T. (2014). "Transdisciplinarity and conceptual change", *World Futures*, Routledge, 70, 200–232. doi: 10.1080/02604027.2014.934635
- McIntire, J., and Dobermann, A. (2023). "The CGIAR needs a revolution", *Global Food Security*, Elsevier, 38:100712. doi: 10.1016/J.GFS.2023.100712
- Meinke, H., Ash, A., Barrett, C. B., Smith, A. G., Graff Zivin, J. S., Abera, F., et al. (2023). "Evolution of the one CGIAR's research and innovation portfolio to 2030: approaches, tools, and insights after the reform", *Npj Sustainable Agriculture*, Nature Publishing Group, 1:1–8. doi: 10.1038/s44264-023-00005-x
- Midgley, G., and Lindhult, E. (2021). "A systems perspective on systemic innovation", *Systems Research and Behavioral Science*, John Wiley & Sons, Ltd, 38:635–670. doi: 10.1002/SRES.2819
- Nelson, V., and Morton, J. (2020). CGIAR Research Program 2020 Reviews: Climate Change, Agriculture and Food Security. Rome.
- Núñez-Ríos, J. E., Aguilar-Gallegos, N., Sánchez-García, J. Y., and Cardoso-Castro, P. P. (2020). Systemic design for food self-sufficiency in urban areas. *Sustainability* 2020, Multidisciplinary Digital Publishing Institute, 12:7558. doi: 10.3390/SU12187558
- Núñez-Ríos, J. E., and Sánchez-García, J. Y. (2024). Determining the factors to improve sustainable performance in a medium-sized organization. *Sustainability* 2024 16:6937. doi: 10.3390/SU16166937
- Núñez-Ríos, J. E., Sánchez-García, J. Y., and Ramírez-Nafarrate, A. (2023). Sustainable performance in tourism SMEs: a soft modeling approach. *J. Model. Manag.* 18, 1717–1739. doi: 10.1108/JM2-06-2021-0136
- Paine, S., Foote, J., and Gauld, R. (2025). Principles for embedding learning and adaptation into New Zealand health system functioning: the example of the viable system model. *N. Z. Med. J.* 138, 118–128. doi: 10.26635/6965.6770
- Panagiotakopoulos, P. D., Espinosa, A., and Walker, J. (2016). Sustainability management: insights from the viable system model. *J. Clean. Prod.* 113, 792–806. doi: 10.1016/J.JCLEPRO.2015.11.035
- Panagiotakopoulos, P., Espinosa, A., and Walker, J. (2015). Integrated sustainability management for organizations. *Kybernetes* 44, 984–1004. doi: 10.1108/K-12-2014-0291
- Panagiotidis, K., Tsolakis, N., and Tsigkas, A. (2023). Overcoming critical failure factors in enterprise information systems implementation: a viable system model framework for manufacturing firms. *J. Oper. Res. Soc.* 74, 1670–1689. doi: 10.1080/01605682.2022.2108734
- Paucar-Caceres, A., and Espinosa, A. (2011). Management science methodologies in environmental management and sustainability: discourses and applications. *J. Oper. Res. Soc.* 62, 1601–1620. doi: 10.1057/JORS.2010.110
- Perko, I., del Gaudio, G., and Potocan, V. (2025). Sustainable supply chains – designing a requisite holistic model. *Bus. Ethics Environ. Responsib.* 34, 1188–1200. doi: 10.1111/BEER.12707
- Peters, M. D. J., Godfrey, C. M., Khalil, H., McInerney, P., Parker, D., and Soares, C. B. (2015). Guidance for conducting systematic scoping reviews. *Int. J. Evid. Based Healthc.* 13, 141–146. doi: 10.1097/XEB.000000000000050
- Rahayu, S., and Zulhamdani, M. (2014). "Understanding local innovation system as an intelligent organism using the viable system model case study of palm oil industry in North Sumatra Province" in *Procedia - Social and Behavioral Sciences*, (Elsevier), 115, 68–78. doi: 10.1016/J.SBSPRO.2014.02.416
- Ramírez-Gutiérrez, A. G., Cardoso-Castro, P. P., and Tejada-Padilla, R. (2021). A methodological proposal for the complementarity of the SSM and the VSM for the analysis of viability in organizations. *Syst. Pract. Action Res.* 34, 331–357. doi: 10.1007/s11213-020-09536-7
- Rezk, S. S., and Gamal, S. (2019). The viable system model and its applications in higher education: an overview. *Kybernetes* 48, 438–450. doi: 10.1108/K-04-2018-0185
- Robinson, O. C., and Bailey-Rodriguez, D. (2026). Deductive qualitative research: an integrative approach to designing studies. *Qual. Res. Psychol.* 23, 369–384. doi: 10.1080/14780887.2025.2604773
- Rummler, G. A., and Brache, A. P. (2012). *Improving Performance: How to Manage the White Space on the Organization Chart*. San Francisco: John Wiley & Sons.
- Rummler, G. A., and Brache, A. P. (2013). *Improving Performance: How to Manage the White Space on the Organization Chart*. 3rd Edn San Francisco: Jossey-Bass.
- Sánchez-García, J. Y., Ramírez-Gutiérrez, A. G., Núñez-Ríos, J. E., Cardoso-Castro, P. P., and Rojas, O. G. (2019). Systems thinking approach to sustainable performance in RAMSAR sites. *Sustainability* 11:6469. doi: 10.3390/SU11226469
- Sankaran, S., Müller, R., and Drouin, N. (2020). Creating a 'sustainability sublime' to enable megaprojects to meet the United Nations sustainable development goals. *Syst. Res. Behav. Sci.* 37, 813–826. doi: 10.1002/SRES.2744
- Schwaninger, M. (2015). "Organizing for sustainability: a cybernetic concept for sustainable renewal", *Kybernetes*, Emerald Group Publishing Ltd., 44, 935–954. doi: 10.1108/K-01-2015-0008/FULL/PDF
- Schwaninger, M. (2018). Systemic design for sustainability. *Sustain. Sci.* 13, 1225–1234. doi: 10.1007/s11625-018-0538-5
- Schwaninger, M. (2019). Governance for intelligent organizations: a cybernetic contribution. *Kybernetes* 48, 35–57. doi: 10.1108/K-01-2018-0019
- Schwaninger, M., and Scheef, C. (2016). A test of the viable system model: theoretical claim vs. empirical evidence. *Cybernet. Syst.* 47, 544–569. doi: 10.1080/01969722.2016.1209375
- Sen, S. K., and Ongsakul, V. (2018). Urban climate-proof finance for disaster-resilient infrastructure: issues on competitiveness and sustainability. *Environ. Urban. ASIA* 9, 127–137. doi: 10.1177/0975425318783546
- Singh, A. K., Pathak, D. K., and Patra, S. (2023). An integrated systems thinking approach for achieving sustainability in project-based organizations. *Syst. Res. Behav. Sci.* 40, 501–535. doi: 10.1002/SRES.2892
- Solano García, P., Ramírez-Gutiérrez, A. G., Morales Matamoros, O., and Coria Páez, A. L. (2025). Viable and sustainable model for adoption of new technologies in industry 4.0 and 5.0: case study on pellet manufacturing. *Applied System Innovation* 8:14. doi: 10.3390/ASI8010014
- Štrukelj, T., Zlatanović, D., Nikolić, J., and Sternad Zabukovšek, S. (2021). The viable system model's support to social responsibility. *Kybernetes* 50, 812–835. doi: 10.1108/K-12-2019-0860
- Sydelko, P., Espinosa, A., and Midgley, G. (2024). Designing interagency responses to wicked problems: a viable system model board game. *Eur. J. Oper. Res.* 312, 746–764. doi: 10.1016/J.EJOR.2023.06.040

- Tavella, E., and Franco, L. A. (2015). Dynamics of group knowledge production in facilitated modelling workshops: an exploratory study. *Group Decis. Negot.* 24, 451–475. doi: 10.1007/s10726-014-9398-2
- Tavella, E., and Papadopoulos, T. (2017). Applying OR to problem situations within community organisations: a case in a Danish non-profit, member-driven food cooperative. *Eur. J. Oper. Res.* 258, 726–742. doi: 10.1016/j.ejor.2016.08.065
- Tejada, G., Cracco, M., Bouleau, C.R., Bolay, J.C., and Hostettler, S. (2019). “Testing analytical frameworks in transdisciplinary research for sustainable development”, *Sustainability 2019, Vol. 11, Page 4343*, Multidisciplinary Digital Publishing Institute, 11:4343, doi: 10.3390/SU11164343
- Timmermans, S., and Tavory, I. (2012). Theory construction in qualitative research: from grounded theory to abductive analysis. *Sociol Theory* 30, 167–186. doi: 10.1177/0735275112457914
- Tong, A., Calvo, J., and Haapala, K. R. (2018). Integration of sustainability indicators and the viable system model towards a systemic sustainability assessment methodology. *Syst. Res. Behav. Sci.* 35, 564–587. doi: 10.1002/SRES.2553
- Tong, Q., Ming, X., Zheng, M., Zhang, X., and Wang, Z. (2022). An innovative model of smart product service ecosystem (SPSE) on sustainability: survival system model, value emerges, and a case study. *Sustainability* 14:12361. doi: 10.3390/SU141912361
- Türke, R. E. (2006). Towards productive and sustainable forms of interaction in governance. *Kybernetes* 35, 164–181. doi: 10.1108/03684920610640290
- United Nations Department of Economic and Social Affairs (2020) “SDG Indicators: Metadata repository” United Nations Available online at: <https://unstats.un.org/sdgs/metadata/> (Accessed July 4, 2023)
- Vahidi, A., Aliahmad, A., and Teimouri, E. (2019a). Evolution of management cybernetics and viable system model. *Syst. Pract. Action Res.* 32, 297–314. doi: 10.1007/s11213-019-9478-y
- Vahidi, A., Aliahmadi, A., and Teimoury, E. (2019b). Researches status and trends of management cybernetics and viable system model. *Kybernetes* 48, 1011–1044. doi: 10.1108/K-11-2017-0433
- Vik, M. B., Finnestrand, H., and Flood, R. L. (2022). Systemic problem structuring in a complex hospital environment using viable system diagnosis – keeping the blood flowing. *Syst. Pract. Action Res.* 35, 203–226. doi: 10.1007/s11213-021-09569-6
- Yahner, M., Muriuki, A., Mangieri, A., Ara Nitu, S. N., Shafinaz, S., and Sarriot, E. (2022). Designing for impact and institutionalization: applying systems thinking to sustainable postpartum family planning approaches for first-time mothers in Bangladesh. *Glob. Health Sci. Pract.* 10. doi: 10.9745/GHSP-D-22-00023/-/DCSUPPLEMENTAL