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Generative AI applications in system dynamics modelling

Masoud Fakhimi [a], **Seyed Hossein Hosseini** [b]

[a] *Surrey Business School, University of Surrey, Guildford, UK,* [b] *Youth Mental Health and Technology, Brain and Mind Centre, Faculty of Medicine and Health, Central Clinical School, University of Sydney, Newtown, NSW, Australia*
Email: seyedhossein.hosseini@sydney.edu.au

Abstract: System Dynamics (SD) remains a widely used approach for modelling complex systems and analysing their behaviour over time. Its applications span health, environmental sustainability, urban planning, and organisational strategy—helping to uncover policy resistance, unintended consequences, and leverage points for change (Zanker et al. 2021). Yet, despite this breadth, SD practice remains highly manual and confronts several entrenched challenges: reliance on outdated workflows, limited integration of advanced computation and data, over-aggregated compartment models that overlook heterogeneity and network effects, and insufficiently rigorous approaches to eliciting and validating mental models (Sterman, 2018; Hoffmann et al. 2025).

Recent advances in Generative AI (GenAI)—particularly Large Language Models (LLMs) such as GPT-4 — create new opportunities to augment each stage of the SD modelling lifecycle. GenAI systems now excel at text generation, summarisation, dialogue, question answering, and code synthesis (Chang et al., 2023), positioning them as potential co-participants in many language-rich tasks central to SD. However, the literature still lacks a systematic account of how GenAI is currently employed, what roles it fulfils, and how these roles align with the SD modelling process.

To address this gap, the present study reviews emerging techniques, trends, applications, and research opportunities at the intersection of GenAI and SD modelling, and proposes a role-based classification framework that maps GenAI contributions to the stages articulated by Sterman (2000). The framework, grounded in observed practice, experimental tool use, and modeller–AI interactions, highlights GenAI support for problem articulation, dynamic hypothesis development, systems mapping—encompassing subsystem diagrams, causal-loop diagrams, and stock-and-flow diagrams—model formulation, model testing, scenario exploration, policy evaluation, documentation, and interpretation. Six functional roles are distinguished—conceptual assistant, structure generator, narrative translator, dialogue facilitator, scenario explorer, and capacity builder—each defined by characteristic interactions shaped by prompt design, modelling context, and analytical aims.

The purpose of this study is to clarify how GenAI is currently deployed in SD modelling, what discrete roles it assumes, and what these roles imply for both research and practice. By making the roles explicit and analytically distinct, we offer a foundation for the systematic integration of GenAI into SD workflows, while also foregrounding critical questions about validity, transparency, and epistemic boundaries when models are co-developed with non-human agents.

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