Seven Years of Trying to Help Understand and Improve Systems

Lessons Learned from Practicing System Dynamics in the Public Sector

Dr. Erik Pruyt & Dr. Tushith Islam

Center for Policy Exploration Analysis and Simulation

PEAS Center BV, The Hague, The Netherlands. www.peas.center

ABSTRACT

After nearly 20 years of teaching System Dynamics (SD) modelling and simulation and being deeply involved in methodological and applied SD research, Erik Pruyt left the ivory tower of academia and ventured with a small group of like-minded researchers into the real world, practicing what he had preached for many years, but also learning many lessons about applying SD outside of academia to make the world a better place. Tushith Islam is one of the like-minded researchers specialized in data science, scripting, and developing new approaches. They decided to share some of the lessons learned at the ISDC2026.

Their SD approach was and still is largely quantitative, mostly data-rich, focused on uncertain systemic and dynamic challenges, often "grand" challenges, usually dealt with by public sector agencies or governments. Confronted with the real-world context outside of academia, they learned a lot about real-world contexts and adapted most of the SD tools in their toolkit.

This proceedings paper is a shortened version of the conference paper in which they presented systems insights, adaptations to the traditional SD method (to have an impact in the real-world), and lessons learned about practicing systems modelling and simulation outside of academia and research institutes.

1. INTRODUCTION

From 2000 till 2019, Erik Pruyt worked in academia – most of this time as a professor of System Dynamics (SD) and quantitative Policy Analysis courses at Delft University of Technology. I taught SD to thousands of students in a variety of SD courses. Most of these students had to take both an introductory SD course and an intermediate project course. A smaller group of students also followed an advanced SD course. Erik was involved in some thousands of student projects, ranging from projects for project courses to thesis projects, many of which were directly or indirectly for external organizations. As real world as they get in Academia.

Apart from that, Erik conducted both methodological research in SD and used SD for applied research. Apart from teaching, doing and supervising research, he actively served the public sector on projects related to energy transitions and climate change, sustainability and development, humanitarian issues and migration, safety and security, infrastructure, and health. The reasons for doing so, and not solely focusing on an academic career, were that he strongly believe teaching should be rooted in practice, that professors need to know what they are talking about and that there is a need outside of academia for SD thinking and modelling.

After almost 20 years in academia, he decided to leave academia to apply SD professionally in the public sector. He hoped it would allow him to dedicate most of his time to solving important challenges. Tushith Islam, a formed post-doc from TU Delft with experience in data science and

scripting for SD, joined from the very beginning. After 7 years outside of the ivory tower of academia, they felt it was time to share some of their lessons learned.

This paper is a short version of the conference paper, leaving out many of the lessons learned that will first and foremost make AI smarter. The full conference paper is available for interested readers upon request. The contents of the longer conference paper will also soon be published in a soon-to-be finished book on *Intermediate System Dynamics Modelling and Simulation* (Pruyt, 2027 forthcoming) and in a chapter on *System Dynamics Modelling and Simulation in Practice* in an *Advanced System Dynamics Modelling and Simulation* book scheduled for release in 2027 (Pruyt and Islam, 2027 forthcoming). The intermediate book and advanced book will complement many of the books we developed for students and practitioners of systems modelling and simulation, including the second edition of the *Small SD Models for Big Issues* book (Pruyt, 2026), and the books in the *Systems Modelling and Simulation for Everyone* series. The books in that series target specific domains and domain experts and are used to teach workshops offered by the PEAS Center, Center for SYSTEMS, and Policy Academy & ReThink Institute. Following books/domains are (or will soon be) offered in the *Systems Modelling and Simulation for Everyone* series:

- Sustainability, Circularity, Transitions
- Epidemiology, Population Health
- Migration, Displacement, Asylum
- Safety, Security, Public Order
- Climate Change, Mitigation, Adaptation
- Nature, NbS, Ecosystems, ESSs, Biodiversity
- Agriculture, Biobased Economy, Land Use, LUChange
- Contamination, Env. Risk Assessment, Remediation
- Economics, Capitals, Wealth, Welfare, Wellbeing
- Economics, Productivity, Labour, Education, Innovation, Markets
- Infrastructure and Dynamic Asset Resource Management

The *Intermediate System Dynamics Modelling & Simulation* book provides in depth discussions of and learning of Data-Rich SD Modelling (without Python scripting); Operational versus Non-Operational Modelling; Modelling Complex Structures and Mechanisms; Policy Testing in Practice: Levers and Leverage; Serious SD Gaming and Lego Game Prototyping; System Dynamics in Practice: Learning from Failure.

The *Advanced System Dynamics Modelling & Simulation* book deals with: Multi-Scale SD Modelling / Entity-Based Modelling; Multi-Dimensional Data Data-Rich Systems Modelling (with Python Scripting); Developing Digital Twins and Building Blocks for Digital Twins; Advanced Analysis to Do More with SD Models; Deep Uncertainty and Robust Decision Making; Advanced Systems Modelling in Practice.

2. SOME OBSERVATIONS FROM APPLYING SD (IN THE PUBLIC SECTOR)

There are many observations that could be discussed here. Many were discussed in the full paper and at the conference. They are not in this short paper.

There are many situations and issues for which SD is perfectly suited. But there are many reasons why organizations are reluctant to hire external modelers and analysts to solve their issues. This

is a pity, because there are many issues in the public sector that would greatly benefit from SD and many public sector organizations are affected by them in similar ways.

Many public sector issues and grand challenges are long-term planning issues/challenges. SD is ideally suited for long-term planning issues/challenges characterized by system inertia. Since there is little long-term planning, there are also many crises because of a lack of long-term planning in the past.

Often, public sector organizations try to solve these crises and long-term planning problems by themselves, or with the help of traditional consultants (i.e., consultants that do not use broad systems boundaries, systems mapping, modelling and simulation to analyze system dynamics).

Consequently, organizations in the public sector keep reinventing the wheel, implementing many measures without understanding the system, developing their own traps (e.g., rework cycles), shifting the burden to intervenors (who do not help them develop their own capabilities), and consequently, they keep experiencing crisis after crisis.

We are not saying organizations and individuals in such organizations are not doing good jobs. In many respects they do. At some, they excel. For instance, many people and organizations are great at making long lists of measures to change a system. However, they do this without being able to assess how these measures affect the system and what the resulting (side) effects are. In some of our recent assignments, excellent lists of many dozens of measures to deal with the issues at hand had been developed, but without any overview of the system and without the slightest idea where and how these measures would affect the system. One big eye opener for us was that systems mapping is not as obvious as we thought it was. It is either a rare skill or a rarely applied one. In almost all assignments over the past seven years, there was a fundamental lack of understanding of the system itself, let alone the larger system in which it is embedded.

Moreover, often there is hardly any desire to really understand the system. There may be many reasons for that. It may not be lack of knowledge. It may just be easier to do what one is supposed to do or has been doing for a long time on autopilot. It may not be what one wants or thinks is expected: people seem to identify strongly with their department, role, job description. One and the same person may be showing very different preferences and behaviors as a production manager than as a sustainability manager; being in the circularity group of the sustainability department may well mean that circularity is the prime goal, even if it may go counter to sustainability. Generally, people are more loyal to their team than to the world.

Official narratives or theoretical models do not cover how things really work in organizations, while how things really work is what matters when mapping the underlying system. Insiders need to be willing to share this information or share data from which it can be derived. Especially in times of crises, critical information and data are kept inside, and major blind spots remain unmentioned.

NB: PAGES INTENTIONALLY TAKEN OUT OF THE CONFERENCE PAPER.

CONTACT US IF YOU WANT TO KNOW MORE.

Apart from many observations about practicing SD successfully and unsuccessfully in practice, there are some problematic regulating mechanisms we see over and over and over again. In the next section, one of them will be discussed on a rather high level of abstraction.

3. ERRONEOUS FLOW-BASED REGULATION

In many of the real cases we worked on, there is a failure in how the system is regulated. To us, by now, it is an archetype with a key stock-flow structure. It arises from the focus on an important flow in the system without recognizing that it is not the flow but 2 stock-flow structures that matter. This “archetype” shows itself best when the system is brought back to its stock-flow essence.

In the conference paper we discussed many such issues and showed models and diagrams. These examples were purposefully taken out of this proceedings paper. Contact us if you are interested.

NB: PAGES INTENTIONALLY TAKEN OUT OF THE CONFERENCE PAPER.

CONTACT US IF YOU WANT TO KNOW MORE.

In sum, it is all about the capacity of systems and how they are regulated, which in turn depends on the capability of those in charge of these systems to reflect systemically about them.

4. FROM TRADITIONAL SD TO OUR OWN VERSION: ADAPTATIONS TO THE SD METHOD

These real-world experiences and recent developments in ICT/AI have changed the way in which we practice SD – not fundamentally, but in ways that are worth talking about in the SD community.

Before going into details about adaptations of my/our SD practice, it is important to understand where we come from in terms of SD background.

Our initial philosophical stance could be referred to as critical realist, with a strong inclination towards scientific knowledge, analytics and data, and with a strong belief that we need to deal seriously with uncertainty. We have a strong preference for operational models. Our main idols in SD are Dana Meadows (2008), Andy Ford (2010), and Jack Homer (2012). Therefore, our practice could be characterized as predominantly quantitative SD, merging science, lots of data and tacit knowledge in operational models, that are subsequently used to identify important systems insights and no-regret policies. We hugely prefer sharing insights and policy recommendations in person with clients, without much linear report writing. We mostly develop multi-scale data-rich SD models and apply Deep Uncertainty approaches.

For me, important elements of SD were (when venturing out in the real world):

1. The powerful visual language and diagrammatic conventions: I literally think in terms of model structures.
2. The combination of *operational* modelling (cows produce cow milk, so no cow milk in a model without cows) with broad *systems* modelling of all "side" effects (milk cows need to calve regularly to keep up milk production, and means calves are born, most of which are slaughtered early to end up as meat for human consumption)
3. Stock-flow structures, both quantitative and qualitative, and the importance of (undesired) accumulation and (desirable) buffering – personally, I think there is insufficient attention to Stock-Flow structures (except by practitioners in the tradition of Kim Warren (2008)),
4. And – closely related to stock-flow systems – delays,
5. Feedback loops, as well as other elements that generate non-linear systems behavior,
6. The ability to simulate dynamic behavior and explore effects on the spot
7. The ability to analyze overall system dynamics and functioning of (sub)systems, nd the ability to use SD in combination with EMA to investigate effects of uncertainties but also of the system itself
8. Important ideas regarding leverage
9. Systems insights are what matters
10. Interactive use of models (models should be used)

These elements are still important to us. However, after 7 years of practicing, we realize that these elements are not enough in practice. Hence, our SD practice was extended with:

NB: PAGES INTENTIONALLY TAKEN OUT OF THE CONFERENCE PAPER.

CONTACT US IF YOU WANT TO KNOW MORE.

One of the major eye openers are the physical boundary objects and serious games we develop with Lego.

NB: PAGES INTENTIONALLY TAKEN OUT OF THE CONFERENCE PAPER.

CONTACT US IF YOU WANT TO KNOW MORE.

5. AND LAST BUT NOT LEAST: A FEW REFLECTIONS ON (ORGANIZATIONAL) CULTURE

The changes discussed in section 4 make a very big difference. However, none of these changes works if the reigning culture is not receptive. For us, one of the main considerations to work for ministries/organizations and with specific individuals or not is their culture. We have seen a lot...

NB: PAGES PURPOSEFULLY TAKEN OUT OF THE CONFERENCE PAPER.

THANKS

We would like to thank our current and past clients, collaborators, and students who inspired us to write this paper. We would like to thank the SDS team (Christina, Meagan, Rebecca, and Roberta for the legacy), the ISDC 2026 team, the anonymous reviewers, and the ISDC 2026 conference participants for great interactions (and for awarding us a Best Poster Award for this contribution). And last (but not least): we would like to thank anyone who tries to make the world a better place for doing so. Thank you, keep up the good work!

CONTACT

For questions or requests related to Systems Modelling and Simulation, please contact Erik at PEAS dddddot center.
For questions or requests related to advanced Data Science, Data handing for SD, Scripting, contact Tushith at PEAS ddddddot center.

REFERENCES

Beer, S., 1985. Diagnosing the System for Organizations. John Wiley and Sons: Chichester.

Ford, A., 2010 (2nd ed.). Modeling the Environment. Island Press: Washington.

Homer, J., 2012. Models that Matter. Selected Writings on System Dynamics 1985-2010. Grapeseed Press

Meadows, D.H., 2008. Thinking in Systems. Chelsea Green Publishing: White River Junction.

Pruyt, E., 2027 (forthcoming). *Intermediate System Dynamics Modelling and Simulation*. Center for SYSTEMS: The Hague.

Pruyt, E. 2026. *Small Models for Big Issues; Triple Jump towards Real-World Dynamic Complexity*. Second Edition. Center for SYSTEMS: The Hague.

Pruyt, E. 2026. *Sustainability, Circularity, Transitions*. Center for SYSTEMS: The Hague.

Pruyt, E. 2026. *Epidemiology, Population Health*. Center for SYSTEMS: The Hague.

Pruyt, E. 2026. *Migration, Displacement, Asylum*. Center for SYSTEMS: The Hague.

Pruyt, E. 2026. *Safety, Security, Public Order*. Center for SYSTEMS: The Hague.

Pruyt, E. 2026. *Climate Change, Mitigation, Adaptation*. Center for SYSTEMS: The Hague.

Pruyt, E. 2026. *Nature, Nature-based Solutions, Ecosystems, Ecosystem Services, Biodiversity*. Center for SYSTEMS: The Hague.

Pruyt, E. 2026. *Agriculture, Biobased Economy, Land Use, Land Use Change*. Center for SYSTEMS: The Hague.

Pruyt, E. 2026. *Contamination, Environmental Risk Assessment, Remediation*. Center for SYSTEMS: The Hague.

Pruyt, E. 2026. *Economics, Capitals, Wealth, Welfare, Wellbeing*. Center for SYSTEMS: The Hague.

Pruyt, E. 2026. *Economics, Productivity, Labour, Education, Innovation, Markets*. Center for SYSTEMS: The Hague.

Pruyt, E. 2026. *Infrastructure and Dynamic Asset Resource Management*. Center for SYSTEMS: The Hague.

Pruyt and Islam, 2027 (forthcoming). Advanced System Dynamics Modelling and Simulation. Chapter: *System Dynamics Modelling and Simulation in Practice*. Center for SYSTEMS: The Hague.

Warren, K., 2008. Strategic Management Dynamics. John Wiley and Sons: Chichester