

Guest Editorial

Natural Resource Management: Contributions of System Dynamics to Research, Policy and Implementation

Selected papers from the Seventh European System Dynamics Workshop, at University of Bergen, Norway

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INTRODUCTION

This special issue contains a series of papers in the area of System Dynamics modelling (Forrester, 1961; 1968). Perhaps System Dynamics – SD - has not always been at the centre of ‘Systems Science’ in institutional terms. It is also distinctive in terms of some of its ideas: employing the framework of Richardson (1991), SD grew out of a ‘servo-mechanisms thread’ of feedback thinking, in contrast to the ‘cybernetics thread’ from which rather more systems approaches developed. However, looking more broadly one can see that SD is firmly grounded in the notion that holistic thinking provides a better way of understanding the world and of crafting effective interventions.

The project to draw SD into the family of systems approaches is now well into its third decade and has involved connections being made from outside SD by mainstream system scientists (e.g. Bloomfield, 1982; Jackson & Keys, 1984; Keys, 1988) and from within SD itself (Richardson, 1991; Lane, 1994) to the point that SD is frequently treated as self-evidently being a member of the range of systems approaches (e.g. Jackson, 2003). An indicator of this is this journal’s interest in the subject generally: SD is one of the journal’s designated systems fields and therefore has its own editor and the number of SD submissions and publications continues to rise. Further evidence of SD’s embrace by Systems Science is this journal’s support for the ‘European System Dynamics Workshop’ (EuSDW) series, bi-

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annual workshops held in a European location. The most recent was held in Norway in November 2015. The contents of this issue derives from papers presented at that workshop, with their focus being the various ways in which SD can contribute to research and policy formulation and implementation in the area of natural resource management.

IN MEMORIAM

The time between the EuSDW-VII workshop in late 2015 and the production of this special issue saw the death of Jay Wright Forrester (Haffner, 2016). Forrester's emergence as one of the great innovators in the area of Systems Science resulted from his involvement in, and contribution to, a dizzying and deeply impressive range of fields, from servo-mechanism theory, to computer memory, through management information systems and on to SD itself. His remarkable life is described in his own accounts (Forrester, 1990; 1992; 2001; 2002; 2007) and by those of others (Evans, 1983; Lane, 1998; Fisher, 2005; Lane, 2006; 2007; Lane & Sterman, 2011; 2017 forthcoming) and merits study by anyone interested in systems ideas. His work stands as an example of research at its finest, and as an exemplar of the use of systems approaches to improve the world. We respectfully offer this special issue as a small indicator of the legacy of Jay Wright Forrester (1918-2016).

THE EUSDW WORKSHOP SERIES

The Bergen meeting was the most recent in a series. What we now think of as the very first European System Dynamics Workshop took place in Mannheim in March 2003. To date the following EuSDWs have taken place:

Date	Location	Theme
2003	Universität Mannheim, Germany	Rationality in System Dynamics: Modelling Human and Organizational Decision Making
2005	Radboud University, Nijmegen, The Netherlands	System Dynamics in Organizational Consultation: Modelling for Intervening in Organizations
2007	University of St. Gallen, Switzerland	Theory Building with System Dynamics
2009	University of Palermo, Italy	Public Sector Applications of the System Dynamics Approach
2011	Frankfurt School of Finance & Management, Germany	Developing Sustainable Strategies with System Dynamics
2013	Koç University, Istanbul, Turkey	Health, Demographic Change, and Well-being: The European Union's Horizon 2020 Program and System dynamics

So far, each of these workshops has produced a special issue. For convenience, references to the associated special issues of SR&BS may be found at the end of this Introduction, via the citations Lane et al. (2004; 2006; 2008; 2010; 2012; 2015).

The first workshop was the work of Andreas Größler and Peter Milling. We are deeply grateful to them for the idea and for their creation of a sound and useful format for the workshops, a format which we have shamelessly and happily followed.

A WORKSHOP IN BERGEN

Bergen (originally Bjorgvin) is a city of more than a quarter of a million inhabitants on the West coast of Norway. Founded in 1070, it is surrounded by exquisite mountains and enjoys a large, ice-free harbour. Always an important fishing and trading centre, in the thirteenth century Bergen was the capital of Norway for a period and it became the most Northern element of the Hanseatic League. The Bryggen, Bergen's old quayside where the Hanseatic traders lived, is a UNESCO World Heritage Site.¹ The composer and music director Edvard Grieg and the composer and virtuoso violinist Ole Bull were born in the city. Grieg's home, Trolldhaugen, is now a beautifully situated museum and the city centre has both a statue of Bull and the Grieg Hall concert venue. The largest theatre in Bergen is 'Den Nationale Scene' (English: the National Theatre); the world-renown playwright Henrik Ibsen worked there as writer, director and producer. Today, Bergen is the second largest city in Norway. It is known for its oil export activities and has one of Europe's largest harbours. The port is home to the largest merchant fleet in Scandinavia and is also the Norwegian Navy's main base. From a tourist perspective, Bergen is 'the Gateway to the Fjords' and every opportunity should be taken to visit Slartibartfast's award-winning, lovely crinkly edges which, we are old-fashioned enough to think, give a lovely Baroque feel to a continent (Adams & Perkins, 1985)². It is a charming, and beautiful place to visit (see Figs. 1).

Insert Figs. 1 near here

Bergen had hosted the 2000 International Conference of the System Dynamics Society,³ a fact that is elaborated on more in the afterword to this special issue (Strohhecker, 2017) While participants of the 2000 conference were able to enjoy the long summer days in July and wonderful weather during the conference banquet, participants of the 7th European System Dynamics Workshop in 2015 not only experienced the long winter nights in November but also what Bergen is probably most (in)famous for: rain in many shapes and intensities. The last ten years have seen some dubious meteorological records, such as 85 consecutive days of rain in 2006/2007 or, 2016, the wettest July in 46 years. Climate projections are quite unambiguous: it will rain even more and there will be more rainstorms that will also be more powerful (Norsk klimaservicesenter, 2016). The theme of the 2015 EuSDW-VII thus seemed quite fitting.

¹ See: <http://whc.unesco.org/en/list/59>

² See: www.youtube.com/watch?v=nGcBmlDTcHo

³ See: www.systemdynamics.org/conferences/2000/index.htm

The Universitetet i Bergen was founded in 1946 – although academic activity took place at Bergen Museum as far back as 1825. With some 16,000 students and 3,600 employees it is a medium-sized European university. Six faculties cover most of the traditional university disciplines. In addition to research and education in these disciplines, the ‘Strategy for the University of Bergen 2016-2022’ highlights three strategic focus areas: marine research, global social challenges, and climate and energy transition. Issues relating to the environment, resources and climate are also a high priority research field for the Faculty of Social Science. The topic of the 2015 European System Dynamics Workshop ‘Natural Resource Management: Contributions of System Dynamics to Research, Policy and Implementation’ was therefore a perfect fit with these higher-level research priorities.

The University of Bergen has produced a number of famous alumni such as the current Norwegian Prime Minister, Erna Solberg, the second female Prime Minister of Norway. Most importantly in our context, the University of Bergen established an international Master degree program in System Dynamics as far back as 1995 (Davidsen, *et al.*, 2014). The 7th European System Dynamics Workshop thus coincided with the 20 year anniversary of the System Dynamics Group at the University of Bergen, which was, of course, all the more a reason for celebration. The System Dynamics Group now offers two master degree programs in System Dynamics that bring up to 60 students to Bergen for the modelling courses in the Autumn semester: the Master Programme in System Dynamics⁴ and the Joint European Master Programme in System Dynamics EMSD.⁵ It was wonderfully fitting that one recent graduate of the EMSD program was a contributor to the 7th European System Dynamics Workshop and to this special issue (Herrera, 2017).

Insert Figs. 2 near here

The University of Bergen – like many facilities in the city – is merely a short walk from the harbour. Participants gathered informally the evening before the workshop and dined in the city centre. As the sky darkened, the lights on the surrounding hillsides magically emerged. On the morning of the workshop itself, in the Auditorium of Jekteviksbakken 31, the local organiser announced that the event would indeed be a WORKshop - and that the group of Northern Europeans sitting isolated in the middle of the lecture theatre could not be allowed. Lured additionally by the promise of power sockets, they were encouraged to move to the front row. And the event proper began (Figs. 2). A more formal gathering at the *Literaturhuset* (‘the house of literature’) followed the first day of the workshop. A literature search was seldom more enjoyable and in this convivial setting participants offered their thanks to the organisers. A further half day session followed (Figs. 3).

Using the general model of the workshop series, first, Authors gave a talk on their research project or topic, these having been invited on the basis that they contributed to the broader theme of the workshop, their papers having been circulated to invitees some weeks previously. A designated Discussant then responded with remarks to critique, support, or add further perspective. In open session, all participants then posed questions and contributed comments. A total of nine talks were given in this way.

Insert Figs. 3 near here

Each of the workshops in the series is designed with its own specific aims in mind and this was no less true of EuSDW-VII. Nevertheless, the guest editors are able to include in this

⁴ See: www.uib.no/en/studyprogramme/MASV-SYSDY

⁵ See: www.uib.no/en/studyprogramme/JMASV-SYSD

special issue a selection of the ideas and projects discussed at EuSDW-VII in the form of research papers. These were developed further, in part in response to comments from all workshop participants, and also as a result of the journal's refereeing processes. Also presented here are papers by the respective 'discussants' at the workshop, providing a sense of the interplay of ideas at the event itself but offering readers here alternative perspectives on the topics of the papers.

A location like Bergen, combined with the intellectual heritage of the host institution, could not but promote trans-disciplinary thinking amongst the European system dynamicists who were able to gather together via the mechanism of the continuing workshop series. The Bergen meeting was the seventh in a sequence of workshops which afford an opportunity for system dynamics researchers spread across Europe to meet with each other and discuss their ideas and work.

NATURAL RESOURCE MANAGEMENT

The topic of the 2015 European System Dynamics Workshop was 'Natural Resource Management: Contributions of System Dynamics to Research, Policy and Implementation'. The choice of this topic was the result of several, complementary considerations. A first, programmatic, consideration was the previously mentioned shared research interest of the System Dynamics Group at the University of Bergen in resource management and sustainable development. Second, the sixth European System Dynamics Workshop in 2013 in Istanbul had started exploring ways in which SD work could be included in the European Union's Horizon 2020 program for research and innovation. The 2015 European System Dynamics Workshop in Bergen aimed at continuing this effort and focused on one of the challenges identified by the Horizon 2020 program for funding: 'Climate Action, Environment, Resource Efficiency and Raw Materials'. The workshop provided an avenue for exploring the current state of European SD research in this area. Such review was also important for an additional reason: January 1st 2016 marked the official launch of the 'Sustainable Development Goals', a set of goals to end poverty, protect the planet and ensure prosperity for all as part of a new sustainable development agenda (United Nations, 2016). One of the key features of these goals is their focus on interconnections within and across goals, as exemplified by the work on the water, food and energy nexus (Kurian, 2017). SD seems to be particularly suitable for supporting work on achieving the goals (Kopainsky, *et al.*, 2017) and an informed discussion about the role of SD in this context at the end of 2015, just before the launch of the 'Sustainable Development Goals', was therefore more than timely.

CONTENTS OF THIS SPECIAL ISSUE

This special issue presents Research Papers in areas relating to the management of natural resources and each paper has a Discussant's Comments. After this Guest Editorial, the special issue therefore contains the following pieces:

1. The issue opens with John Morecroft's paper 'Long-term futures for the upstream oil industry'. He looks at the phenomena of enduring causal structures in social systems – a key idea in SD. By extending his work on the oil production industry he makes the case for the persistence of key causal mechanisms, arguing that recent significant developments – e.g. 'fracking' – can still be seen as residing within enduring feedback processes related to OPEC. The Discussant's Comments that follow are by Etienne Rouwette and he offers 'The Limits To Growth' as a further example of enduring

structure and suggests that working in a domain for an extended period is useful for observing similar examples.

2. This is followed by a research paper by Hendrik Stouten, Hans Polet, Aimé Heene and Xavier Gellynck. Their paper ‘Learning from collaboratively playing with simulation models in policy making: An experimental evaluation in fisheries management’ considers the problem of how people might – or might not – learn when exposed to a model which allows experimentation with the dynamics of a renewable resource and whether there might be a difference between individual and collaborative learning. The Discussant’s Comments by David Lane offers a re-framing of the issue in terms of ‘behavioural science’ and suggests ‘Behavioural System Dynamics’ as a means of researching a range of similar phenomena.
3. The third paper is ‘Analyzing soil nitrogen management with dynamic simulation based laboratory experiments’. In it, Ali Saysel considers the use (and over-use) of nitrogen fertilisers in agricultural production. Using a dynamic simulation model he demonstrates that improved understanding of the best way of avoiding nitrogen accumulation on farmlands can be generated and argues that, if deployed in farming communities, his simulation can lead to more appropriate fertilizer usage rates. Steve Alessi provides Discussant’s Comments in which he proposes ways of further strengthening the research and improving its opportunities for effecting real learning.
4. The fourth research paper is by Hugo Herrera. In ‘From metaphor to practice, operationalising the analysis of resilience using system dynamics modelling’, this author argues that the concept of ‘resilience’ in social-ecological systems is under-developed because of difficulties in both understanding the mechanisms that could be used to improve resilience and in measuring the consequences of potential policies. He uses SD modelling as the platform for improving understanding of the concept of resilience by proposing a set of fundamental characteristics which constitute a ‘resilient’ response to a policy. In his Discussant’s Comments, Hubert Korzilius offers a still broader perspective on the concept of resilience and offers thoughts for future research, seeing the stream of work as possessing considerable value.
5. This is followed by the fifth research paper, a piece by Silvia Ulli-Ber, Merla Kubli, Juliana Zapata, Michael Wurzinger, Jörg Musiolik and Bettina Furrer. Their ‘Participative modelling of socio-technical transitions: Why and how should we look beyond the case specific energy transition challenge?’ considers the problem of how learning about one transition can be transferred, and inform policy making relating to another. The authors use a theorizing framework to explore the different theoretical tools that people use to make sense of their experiences with a model. The Discussant’s Comments by Nici Zimmermann offer a striking perspective which supports the research by appealing to theories concerning ‘meaning making’.
6. The final research paper is ‘Why do some food availability policies fail? A simulation approach to understanding food production systems in south-east Africa’ by Andreas Gerber. He considers the failure of various policies aimed at increasing food availability and proposes three key concepts, derived from SD, which offer more sound theoretical ground upon which policies should be evaluated. In his Discussant’s Comments, Len Malzynski draws on his personal experience of work relating to Gambia and offers an insightful perspective which positions the research in a 150 year history of attempts to improve farming systems.

7. The Afterword is by Jürgen Strohhecker and it brings the special edition to a close with reflections on the workshop and SD' relationship with Bergen.

As guest editors we hope that this collection will be of interest to researchers and practitioners in System Dynamics, Systems Science, OR/MS, natural resource management, and all others interested in understanding complex dynamic systems.

ACKNOWLEDGEMENTS

In our role as guest editors we would like to offer our thanks to everyone who made this special edition possible:-

All those who organised the 2015 EuSDW-VII workshop and who ensured that it ran so well. The referees for this special edition. When finding anonymous referees the Guest Editors drew on the global communities of systems scientists, operational researchers and system dynamicists; their contribution to the issue was vital.

Lesley Fitton of the Department of Greek and Roman Antiquities, and Janet Larkin of the Department of Coin and Medals, both of the British Museum, London, who provided the image from which the symbol used for the workshop series was derived. The owl is taken from the reverse side of a silver *tetradrachm* made in Athens around 480 BC. CM 1906-11-3-2591. Copyright British Museum, London. The symbol for the series of European System Dynamics Workshops was created by David Lane.

Finally, Amanda Gregory and Mike Jackson for inviting us to guest edit this special issue – but also for their steadfast support for the European System Dynamics workshops.

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