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Guest editors' introduction

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This special edition of the *African Journal of Agricultural and Resource Economics* contains a series of papers that utilise systems dynamics to examine various issues relating to the costs and benefits of controlling invasive alien plants (IAPs) and subsequently restoring the land in South Africa. Of the 8 750 exotic species that were introduced into South Africa, 198 are considered invasive (Wilson *et al*. 2013) and have major ecological and socio-economic impacts (Novoa *et al*. 2018). Controlling and managing the invasive species have been a priority of the South African government through the Working for Water Programme. However, the management of the IAPs occurs in a multi-stakeholder environment in which the benefits and costs are borne by different stakeholders, hence giving rise to a challenging and complex issue.

System dynamics is a simulation-modelling approach that is appropriately suited to examining real-world complex issues over time (Sterman 2000; Musango *et al*. 2014). Jay Forrester introduced the field of system dynamics in the mid-1950s, and guidelines for the modelling process are well developed (see Table 1). Its application spans across different disciplines. Further, it has become an important decision support tool for public and private policy design (Probst & Bassi 2014).

Table 1: The system dynamics modelling process across the literature

Randers (1980)	Richardson and Pugh (1981)	Roberts *et al.* (1983)	Wolstenholme (1990)	Sterman (2000)	Moxnes (2009)
Conceptualisation	Problem definition	Problem definition	Diagram construction and analysis	Problem articulation	Problem
	System conceptualisation	System conceptualisation		Dynamic hypothesis	Hypothesis
Formulation	Model formulation	Model representation	Simulation phase (stage 1)	Formulation	Analysis
Testing	Analysis of model behaviour	Model behaviour		Testing	Policy
	Model evaluation	Model evaluation			
Implementation	Policy analysis	Policy analysis and model use	Simulation phase (stage 2)	Policy formulation and evaluation	Implementation
	Model use				

Source: Adapted from Luna-Reyes and Anderson (2003)

The application of system dynamics in agricultural and natural resource economics is not new in South Africa (Crookes *et al*. 2013). The major contribution of this special edition is that the papers emanate from a contract project with the Department of Environmental Affairs: Natural Resource Management (DEA:NRM) on the control of IAPs, hence the results potentially have important implications for natural resource management and policy in the country. Their shared concern is to analyse the benefits of controlling IAPs and restoring the land, along with the costs of doing so. Standard cost-benefit analysis is used as a theoretical framework, but augmented with simulations of ecological and economic dynamics. The main argument contained in the papers of this special issue is that the control of IAPs has economic and, in some cases, direct financial benefits that exceed the costs, although under strict conditions such as the cost and timing of control action, the density of the stands, the cost of various restoration methods, the value of water and carbon, values revealed by private individuals regarding the quality of the environment, and the restoration of land to productive use. Co-financing partnerships with the private sector are suggested as a way to lower the costs to government and securing not only private benefits, but also benefits for the broader society. The rationale for the private business sector to be involved is the incentive to derive financial value from cleared IAPs. In some cases, individuals already derive sufficient value to justify control efforts up to a certain level.

The studies published in this special edition further provide insights into local dynamics and examine the effects of policies using a 'what if' analysis. Undertaking 'what if' analysis in system dynamics is valuable, as it provides insights into the behavioural patterns of IAPs and their control in South Africa. This means that the interpretation of the papers' results should be taken with caution, in that less attention should be paid to numerical values and that the focus should to a greater extent be on behavioural patterns. In brief, the results are not prescriptive, but rather form part of a discussion or set of options for dealing with the complex challenge of managing natural resources with IAPs in a multi-stakeholder environment.

We acknowledge that IAPs constitute both temporal and spatial issues. The papers presented in this special issue focus only on temporal aspects, partly because system dynamics was developed to model non-spatial systems. However, there have been on-going efforts to integrate spatial modelling into system dynamics, as observed in software such as AnyLogic[1] and SIMILE[2]. Priorities for future research on IAPs in the South African context are to integrate spatial aspects into the system dynamics model, recognised as spatial system dynamics (refer Neuwirth *et al*. 2015). Other future research considerations include: (i) exploring system dynamics modelling frameworks that allow for integrating stakeholder deliberation and knowledge with scientific analysis, such as mediated modelling, participatory system dynamics, community-based system dynamics or group model building; and (ii) paying attention to allowing empirical data collection to form part of the validation process in order to improve confidence in the usability of the model's results.

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[1] https://www.anylogic.com/

[2] http://www.simulistics.com/

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