DeSIRE tenure track position #15: Operational Measures for the Assessment of Resilience and Sustainability of Complex Adaptive Systems

University: Wageningen University & Research

Faculty: Plant Sciences Group (Biometris)
Responsible Professor: Prof. Jaap Molenaar

Description:
The aim of this position is to develop methodologies for conceptualizing and quantifying resilience, in particular by using Agent-Based Modelling to describe real-life systems. Resilience and resilience thinking form indispensable ingredients of the current striving for sustainability. One definition of resilience – ecological or 'static' resilience – concerns the properties of systems to deal with disruptions, i.e., to return to a reference state after a disruption. Resilience can then be compared to what happens when a force extends a coil spring: after the force disappears the spring returns to its reference state. In this very simple system resilience is quantified as the maximal allowed extension and by the time it takes for the system to return to the reference state. A completely different aspect – adaptive resilience – applies to the Complex Adaptive Systems (CASs) studied within our 4TU consortium *Designing Systems for Informed Resilience Engineering (DeSIRE)*. In this consortium we study systems like computer networks, cities, agro-food systems, and other human societies. These systems display adaptive capacity and change under the influence of stresses while maintaining their basic structure and functionality, be it a man-made function like a continued production of resources, or a natural function like a population that tries to survive. Quantifying this so-called 'adaptive resilience' is much harder than it is in the simple spring case.

In this TT position Agent-Based Models (ABMs) will be used to describe CASs and develop methodologies for analysing the resilience of these kind of models, in particularly aiming at quantification of resilience. Adaptive capacity emerges from components in CASs with decision- and action-making capabilities – often people or human organizational units – that interact with each other and their environment. ABMs provide a suitable tool for explicitly describing CASs, including their individual components (often referred to as 'agents') and component heterogeneity, by allowing explicit descriptions of rules on interactions, decision-making, and action-taking. Mechanisms for adaptive capacity include learning, cooperation, strategic reasoning, and hereditary or legacy mechanisms in combination with natural selection.

A current drawback of ABMs that limits their application is the lack of methodologies for analysing them. Contrary to, e.g., dynamic system models, for which advanced methodologies like bifurcation analysis and sensitivity analysis methods exist so that a rather complete picture of their resilience can be analysed, many conceptual and computational questions for analysing the resilience of ABMs are still open. Existing packages for sensitivity analysis are not well-suited for handling the dynamic, nonlinear features typical of ABMs.

In this TT new methodologies will be developed for analysing ABMs and quantifying features of adaptive capacity and resilience. To cover a broad application range several case studies from different fields will be involved, including sociotechnical, socioeconomic systems, and socioecological systems.
There is a promising candidate: dr. G.A.K. van Voorn, who at present works at Wageningen Plant Research, a commercial institute for agronomy projects, but who is willing to switch to Wageningen University if this TT comes available.

Position in framework of the programme (please delete what is not applicable):
- Approaches/discipline: mathematical and agent based modelling/ cross-cutting methodologies/ Policy & Governance aspects
- Scale/application area: Agri-Food

Synergy with other tenure track position(s):
- Governing Resilience of the RURBAN Metropolis (UT, Behavioural, Management and Social Sciences)
- Spatial transformation of food systems (UT, Geo-Information Science and Earth Observation)
- Life Course Epidemiology: Modelling Resilience (TU/e, Mathematics and Computer Science)