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EDITORIAL

Uncomfortable knowledge in sustainability science: essays in honor of David Pimentel (1925–2019)

Mario Giampietro[1,2] · Sandra G. F. Bukkens[1] · Maurizio G. Paoletti[2] · Luc Hens[3] · Jingzheng Ren[4] · Tiziano Gomiero[5]

David Pimentel (1925–2019) was a pioneer in the field of agroecology and more in general of sustainability science (for a biography see https://en.wikipedia.org/wiki/David_Pimentel_(scientist)). His work stands out for its breadth and timeliness. Professor of entomology and agroecology at the College of Agriculture and Life Sciences of Cornell University (Ithaca, New York, USA), David Pimentel published more than 500 scientific articles and book chapters, 3 monographs, and 34 edited books spanning a broad range of environmental issues related to socio-economic development. In 1999, together with Luc Hens and Bhaskar Nath, he founded the journal *Environment, Development and Sustainability*.

His work was characterized by transdisciplinarity, and he served as an inspiration for many researchers in the field of sustainability science to broaden their view and embrace a more holistic and critical vision of the functioning of social-ecological systems and human development.

Common sense combined with relatively simple quantitative reality checks, rather than complicated models, was the approach undertaken by David Pimentel to investigate the consistency of the narratives suggested in sustainability science. In this sense, he may be considered an early exponent of 'quantitative storytelling'.

He also adopted a novel teaching approach. Moving away from the dominant reductionistic doctrine, he pushed his students to embrace a system approach, training them in teamwork and addressing real case studies. Often these group exercises resulted in publications in important scientific journals.

✉ Mario Giampietro
Mario.Giampietro@uab.cat

Jingzheng Ren
jingzheng.jz.ren@polyu.edu.hk

1 Institute of Environmental Sciences and Technologies (ICTA), Universitat Autònoma de Barcelona (UAB), Barcelona, Spain

2 Catalan Institution for Research and Advanced Studies (ICREA), Barcelona, Spain

3 VITO - Vlaamse Instelling Voor Technologisch Onderzoek, Dessel, Belgium

4 Department of Industrial and Systems Engineering, The Hong Kong Polytechnic University, Hong Kong SAR, China

5 Mogliano Veneto, Italy

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Most of Pimentel's research addressed wicked environmental problems related to the sustainability of human development, such as biological control, pesticide use, organic and alternative farming practices, soil erosion, loss of biodiversity, genetic engineering, biofuels and biomass energy, fossil energy dependence of the food system, and the relation between population growth and limited natural resources. His capacity to integrate a vast body of knowledge across different scientific fields and to address problems from different perspectives, his free spirit independent from politically correct ideologies and economic interests, and his great intuition, allowed him to bring this often "uncomfortable knowledge" to the attention of the scientific community, policy makers, and lay people alike, in a clear and unequivocal way.

For example, he was among the first scholars to alert to: (i) the dependence of our food system on fossil energy, making us aware that "we are eating oil"; (ii) the significant cost of producing meat, flagging that the USA could feed 800 million people with the grain consumed by livestock; (iii) the unviability and unsustainability of biofuels as alternative energy carriers to fuel modern society; (iv) the risk of increased herbicide use in genetically modified herbicide resistant crops. All this uncomfortable news challenged the sustainability myths of his time (some of which, unfortunately, persist to the present day).

The role of 'uncomfortable knowledge' as Steve Rayner defined it (Rayner, 2012, Economy and Society, pp. 107–125), played a major role in sustainability analysis. As Rayner puts it: "*to make sense of the complexity of the world so that they can act, individuals and institutions need to develop simplified, self-consistent versions of that world … knowledge which is in tension or outright contradiction with those versions must be expunged. This is uncomfortable knowledge which is excluded from policy debates, especially when dealing with 'wicked problems'*".

In line with David Pimentel's attention to wicked environmental problems, this special issue presents a number of contributions that address sustainability discussions in the field of agro-food systems.

In this topical issue, the paper by Crews and Polk illustrates the role for soil conservation and carbon accumulation of developing perennial grain agroecosystems, in an attempt to mimic prairies native ecosystems. Developing perennials, allowing a large-scale production, may represent a turning point toward a truly more sustainable agriculture.

Domínguez et al. explore in depth the advantages of alternative farming systems by expanding the set of criteria for evaluating the performance of food production and considering the nexus between the different factors of production.

Kleinman and Harmel look into the trade-offs of global nutrient redistribution, the analysis of which is essential to identify "challenges of" and "opportunities for" a global transformation to a more sustainable resource management.

Abdul Aziz et al. present an integrated assessment of sustainable foraging knowledge and practices, using examples from different geographic regions, and show that these have an important role to play in the future of sustainable agriculture.

Cadillo-Benalcazar et al. present a model to study the complexity of the society–agriculture–forest system and illustrate it for the case study of Huayopata in Cuzco (Peru), where public policies for tea production interact with the complexity of the society–agriculture–forest system.

Orozco-Meléndez and Paneque-Gàlvez challenge the predominance of the disciplinary vision that shapes the existing "corporate food regime". Using literature review and a conceptual approach they show the need for a transition to another method of governance based on co-design and co-production of uncomfortable, transdisciplinary, and actionable knowledge.

Zanardo et al. address the controversial "horn manure" (Preparation 500) used in biodynamic agriculture. They studied the changes during the manure maturation of the fungal and bacterial communities inside the horns of cows. The analysis suggests that significant changes take place during the process. This work proves that notwithstanding the demonization of biodynamic agriculture as an esoteric quackery, still there are aspects of biodynamic agriculture that can be scientifically investigated.

Giampietro illustrates the "magic" of the unique procedure developed by David Pimentel to quantify systems of agricultural production in terms of profiles of inputs and outputs. This procedure establishes bridges among data referring to different dimensions (social, economic, technical, ecological) and to different scales, when utilizing the patterns of profiles in their scaled form—per hectare—and in the form of technical coefficients—unitary processes.

Ponti and Gutierrez address the important issue of invasive species and their environmental and economic impacts, and argue that it is essential to be able to monitor weather-driven dynamics and potential geographic distribution and abundance. To this purpose, the authors present a new approach—Physiologically Based, Demographic Models (PBDMs)—that avoids the limitations of existing methods.

Alfonso-Bécares et al. use the concept of societal and ecosystem metabolic analysis to study policies of forest conservation. Employing a quantitative characterization based on profiles of inputs and outputs, the authors establish a link between: (i) changes in the heterogeneity of livelihoods found in a given farming system, and (ii) changes in the patterns of land uses. This link is then used to run "what if" scenarios associated with different policy options.

Díaz-Siefer et al. study the factors that prevent a transition to greener agriculture in Chiapas, Mexico, and in particular the type of conditioning that the socio-economic context poses. They identify three relevant actors: (i) the policies and regulation developed by the governments; (ii) the choices of the consumers; (iii) the quantities of subsidies that can be used made available by financial agents and suggest possible adjustments to get out of the impasse.