frontiers | Frontiers in Environmental Science

TYPE Opinion
PUBLISHED 14 November 2023
DOI 10.3389/fenvs.2023.1295590

Indicators for modeling redesign from conventional to sustainable silvopastoral systems –an expert's opinion

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RECEIVED 19 September 2023
ACCEPTED 30 October 2023
PUBLISHED 14 November 2023

CITATION
Gomes Lobo AA, Campana M, Gameiro AH, Mourão GB and De Morais JPG (2023), Indicators for modeling redesign from conventional to sustainable silvopastoral systems –an expert's opinion.
Front. Environ. Sci. 11:1295590.
doi: 10.3389/fenvs.2023.1295590

KEYWORDS

agroforestry systems, environmental impacts, modeling, multifunctional, operational research, redesign

Introduction

A conceptual framework for the assessment of strategies to support the transition from conventional to sustainable agriculture is described by Hill and MacRae (1996), taking the form of an approach to the redesign process in which organizational structures and decision-making procedures are designed to be compatible with ecological "laws" and realities, and these are taken into account in all designs and management procedures. Despite the potential of silvopastoral systems (SPS) as a sustainable type of system for livestock production, there is a lack of development of whole-farm simulation models (Gómez et al., 2020).

Multifunctional and truly sustainable grassland landscapes require expansion of our thinking and narratives beyond narrow discussions informed by greenhouse gas emissions or carbon footprint assessments (Tittonell, 2021). Thus, the development of optimization models for agricultural production systems has aroused the curiosity of scientists since the middle of the 20th century, when the complexity of technical production relationships increased significantly with the advent and use of inputs and technologies responsible for increasing the productivity of plant and animal crops (Gameiro et al., 2010).

The main objective of the work as a whole is to create a modeling framework to guide the redesign of productive landscapes for ruminants in tropical conditions.

Subsections relevant to the subject: novel ideas in modeling of productive landscapes

Mathematical modeling constitutes the simulation of real systems in order to predict their behavior, with the aim of mathematically describing a phenomenon. Furthermore, it can be applied in analyzing the influence of different environmental and biological variables, as well as making it possible to visualize various scenarios of the production system as a whole, by interconnecting a set of systems that seek a common goal, and thus it can help with

10.3389/fenvs.2023.1295590

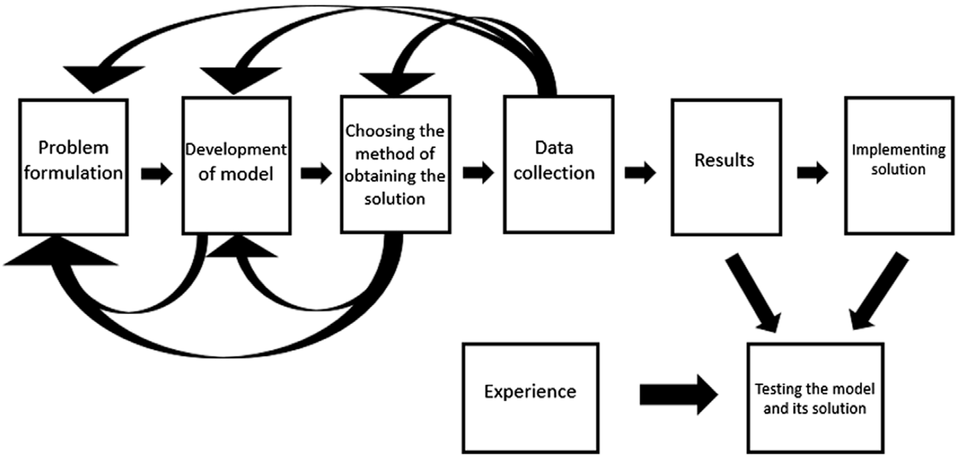

FIGURE 1
Schematization of the phases of a study applying OR.

decision-making for intervention in the system, answering the question: *how can livestock systems be modeled to help farmers redesign their livestock systems for ruminant production?*

In order to find a suitable response capable of changing the reality of family farmers, it is essential to create a tool through mathematical modeling. Given the complexity of the relevant systems in reality, an understanding of cause and effect is created in the model, which is a simplified and idealized representation of reality (Chwif and Medina, 2014).

From this perspective, it is worth mentioning one of the main areas of knowledge related to mathematical modeling with a view to optimization: operational research (OR). The Brazilian Society for Operational Research (SOBRAPO) defines this as an applied science aiming to solve real problems, focusing on decision-making, and applying concepts and methods from various scientific areas in the design, planning, or operation of systems; these are used to evaluate alternative courses of action and identify the solutions that best serve the objectives of individuals or organizations. Through quantitative-based development, operational research also aims to introduce elements of objectivity and rationality into decision-making processes, without neglecting, however, the subjective elements and organizational framework that characterize the relevant problems (SOBRAPO, 2010).

Discussion

The phases of problem-solving through OR according to Marins (2011), in simplified form, can be seen in the flowchart in Figure 1.

However, what will be presented in this context is the 'Experience' (Figure 1), which relies on reports from renowned researchers in their fields in order to contribute to the construction of indicators and parameters for the construction of the model; this will use the deterministic model type *per se*, in which the input data are known, and the research technique is linear programming with an objective function, with the objective of evaluating environmental impacts.

We want to show the importance of expert opinions in conducting scientific work, since this project is derived from FAPESP 2020/16076-0, the first redesign project conducted in Brazil, which covers everything from interviews concerning producers' perceptions to the simulation of the redesigned property.

The experts' contribution to the choice of parameters that will make up the model is refined according to information from the scientific literature and responses to the question of "how do the variables relate to one another?", these variables being soil, plant, and animal parameters, and the ways in which they influence environmental impacts. The answer to this question is useful for decision-making within a ruminant production system and for actions such as public policies, which, in Brazil, are commonly categorized into social, economic, and environmental policies.

To answer the aforementioned question, including the environmental impact component, several interviews were held with 14 researchers working in different multidisciplinary areas, such as administration, animal science, agronomic engineering, forestry engineering, economics, and statistics, in order to identify indicators that could be used as variables in the model; these included parameters such as: fertilization, water deficit, precipitation, nitrogen fixation, soil erosion/compaction, nutrient and soil moisture content, and soil fertility (soil parameters); bromatology, production, availability, accumulation, growth stage, *Urochloa brizantha*, biological control, shade, digestibility, spatial distribution, number of individuals (i.e., density by area), number of species, presence of species such as grasses, shrubs, and trees; carbon sequestration by plants, wood, spacing (design), and the proportion of nutrients in the area available to the animal (plant-related parameters); and stocking rate, carcass yield, age at slaughter, growth rate, mortality rate, mature weight, average daily weight and gain, nutritional requirements, production system (e.g., intensive), breed of animals, mineralization of animals, nitrogen excretion, methane emission, YM (yield methane, i.e., energy lost in the form of methane), health aspects, nutrient dynamics, and energy partitioning (animal parameters).

Conclusion

Under this approach, our research group strongly believes that it will be able to answer the question and solve the proposed problem in relation to environmental impacts.

Author contributions

AG: writing–original draft, Writing–review, and editing. MC: writing–review and editing. AG: writing–review and editing. GM: writing–review and editing. JD: writing–review and editing.

Funding

The author(s) declare that financial support was received for the research, authorship, and/or publication of this article. This research was funded by a grant (process number 2022/14349-4) from the São Paulo Research Foundation (FAPESP).

Acknowledgments

The authors acknowledge and thank the editor and reviewers, as well as the funding body FAPESP (#2022/14349-4) and the host institution, Federal University of Sao Carlos.

Conflict of interest

The authors declare that the research was conducted in the absence of any commercial or financial relationships that could be construed as a potential conflict of interest.

Publisher's note

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