Combining argumentation and system dynamics simulation for decision support in the agri-food sector

Rallou Thomopoulos, Bernard Moulin, Laurent Bedoussac

Combining argumentation and system dynamics simulation for decision support in the agri-food sector

Rallou Thomopoulos*[1], **Bernard Moulin**[2], **Laurent Bedoussac**[3]

1. *INRA UMR IATE / INRIA GraphIK, Montpellier, France;*
2. *Computer Science and Software Engineering Department, Laval University, Quebec, Canada;*
3. *AGIR, Université de Toulouse, INPT, INP-PURPAN, INRA, ENSFEA, 31320, Auzeville, France*

Keywords: model integration, explanatory method, scenario, alternative, intercrop, legumes, cereals

Abstract: In an increasing number of socio-economic domains, high-level decision making such as policy making and strategic planning needs to take into account the often conflicting interests and positions of different groups of stakeholders with the goal of finding solutions that can provide the best trade-offs and build consensus towards their adoption. Moreover, stakeholders would be in a better position to make compromise if they were willing to reach a consensus-based solution and if they clearly understood the positions of the different parties with respect to the attended situation(s). This is not easily achieved, especially in *agri-food chains*, a sector in which stakeholders are prone to tensions, conflicts, policy threats and vertical integration pressure [Balmann et al. 2006]. Such difficult situations usually result from the interactions of extremely complex systems which are in constant evolution and are not well understood, even by the stakeholders that operate in them. In such a context, *dynamic modeling approaches* and *computer simulations* are increasingly recognized as valuable tools to better understand such complex systems and to build useful models for decision making [Perrot et al. 2011]. Consensus building is a conflict-resolution process mainly used to settle complex multiparty disputes [Gray 1989] which allows involved stakeholders to work together to develop a mutually acceptable solution. Gray showed that a consensus-building approach help solving problems that are ill-defined, or issues for which there is disagreement about how they should be defined. Such problems are often characterized by technical complexity, scientific uncertainty and differing perspectives among stakeholders. Hence, there is a need for decision support systems or software (DSS) that can provide decision makers and stakeholders with easy-to-understand and trustworthy means to represent and evaluate problems and the related situations and to plausibly anticipate their evolution under different plausible scenarios.

Interestingly, *Computer-Supported Argumentation Visualization* (CSAV) has been successfully used to tackle ill-structured problems [van Bruggen et al. 2003]. When analysing the arguments put forward by stakeholders for and against a given issue, it has been shown that they form an argument structure emphasizing *support* and *conflict* relationships between arguments. Such a structure can be formalized, modelled and displayed using *Argument Modeling and visualisation software* [van Bruggen et al. 2003] [Thomopoulos et al. 2015]. Although modeling argument structures and explaining argument relationships to stakeholders is quite helpful in helping involved parties understand each other's positions, and thus facilitates the deliberation process [Bourguet et al. 2013], stakeholders have still no mean to anticipate the impacts of adopting any of the debated decision options, let alone to compare them. A way to assess how a given option would influence a stakeholder's situation (i.e. the processes influenced by the attended options/decisions) is to create a scenario (emphasizing factors relevant to the stakeholder) that plausibly shows how this situation would evolve if the decision was enforced. Such scenarios can be developed whenever it is possible to model and simulate the stakeholder's situation in relation to the debated decisions/options. As an example of such modeling approach, *System Dynamics* (SD) has been widely used for the past fifty years to model complex socio-economic systems and to simulate their behavior and evolution in a large variety of domains, in almost any discipline involving policy making and strategic planning [Johnson et al. 2008]. For example, SD has been used to assess food system vulnerabilities [Stave et al. 2014]. However, to the best of our knowledge, there is still no argumentation modeling/reasoning approach (or CSAV) that takes advantage of System Dynamics analysis and simulation to assess and compare scenarios to help stakeholders build consensus while taking into account their possibly conflicting viewpoints. Our project aims at developing such an integrated approach and at creating a decision support software applicable in the agro-food sector.

As a practical application we currently work on an approach to assess various options available to farmers when considering the adoption of cereal-legume intercrops as an alternative to the corresponding sole crop. In a first step arguments expressed by the main actors of the supply chain were collected from scientific publications (Bedoussac et al., 2015; Pelzer et al., 2014) to identify different alternatives/options available to farmers. In a second step an argument model has been developed to structure and visualize the main arguments (positive and negative) in relation to the different farmer's options when considering cereal-legume intercropping instead of sole crop farming. We also figured out that the farmer's gross margin is a simple way to characterize his operational and financial situation, and hence to assess the impacts of the debated options. Moreover, in a third step we used SD to model the farmer's situation, focusing on how the farmer's gross margin (income vs expenses) is influenced by the main factors/parameters that are related to the different studied options. Note that in a SD model some of the variables/parameters are under the actor's control and reflect his choices or decisions while other variables/parameters are not under the actor's control and reflect the influence of external factors (market price, costs of equipment, costs of fertilizers, etc.). The SD model has been calibrated using well-known data sets (for example, evaluate farmer's gross margin with durum wheat sole cropping using low nitrogen input). In a fourth step, we instantiated the SD model for each available option in order to carry out SD simulations and to assess a scenario that plausibly shows to the farmer the effects of adopting this option. In a fifth step, the results of these simulations have been compared and presented in a tabular way to enable stakeholders easily understand the impacts of each option.

To conclude, the proposed approach takes advantage of argumentation analysis to identify arguments and plausible options available to stakeholders, as well as plausible hypotheses related to external factors. Using the SD model, simulations are performed for different scenarios corresponding to different value combinations of external and controlled variables in order to evaluate the outcomes of the options supported by arguments. Moreover, while considering the same alternative options, the SD model can be customized to reflect the particular situations of different groups of stakeholders (for example farmers located in different regions). Hence, the SD simulations and scenario assessments can show how these different groups would be impacted by the different options. Sharing these results among the different groups of stakeholders certainly helps build consensus toward the adoption of more satisfying solutions.

Acknowledgements: Part of this work was supported by Labex Agro ANR-10-LABX-001-01.

References

Balmann A., Dautzenberg K., Happe K., Kellermann K. (2006) On the dynamics of structural change in agriculture, *Outlook on Agriculture*, 35(2), 115-121.

Bedoussac et al. (2015) Ecological principles underlying the increase of productivity achieved by cereal-grain legume intercrops in organic farming. A review. *Agronomy for Sustainable Development*, 35(3): 911-935.

Gray B. (1989) *Collaborating: Finding Common Ground for Multiparty Problems*, Jossey-Bass Publishers.

Johnson T. G., Bryden J., Refsgaard K., Lizárraga S.A. (2008). A system dynamics model of agriculture and rural development : The topmard core model. In *Proceedings of the 107th EAAE Seminar "Modelling of Agricultural and Rural Development Policies", 13p*.

Pelzer et al., (2014) Association de cultures annuelles combinant une légumineuse et une céréale : retours d'expériences d'agriculteurs et analyse. Innovations Agronomiques, 40: 73-91.

Perrot N., Trelea I.C., Baudrit C., Trystram G., Bourgine P. (2011) Modeling and analysis of complex food systems: State of the art and new trends, *Trends in Food Science & Technology*, Volume 22, Issue 6, June 2011, 304–314.

Stave K.A., Kopainsky B. (2014) Dynamic thinking about food system vulnerabilities in highly developed countries: issues and initial analytic structure for building resilience, *In proceedings of the 32nd International Conference of the System dynamics Society*, July 20-24 2014, Delft (The Netherlands).

Thomopoulos R., Croitoru M., Tamani N., 2015. Decision Support for Agri-Food Chains: A Reverse Engineering Argumentation-Based Approach, *Ecological Informatics* 26(2): 182-191.