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Interpreting participatory Fuzzy Cognitive Maps as complex networks in the social-ecological systems of the Amazonian forests

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Social-ecological systems are linked complex systems that represent interconnected human and biophysical processes evolving and adapting across temporal and spatial scales. In the real world, social-ecological systems pose substantial challenges for modeling. In this regard, Fuzzy Cognitive Maps (FCMs) have proven to be a useful method for capturing the functioning of this type of systems. FCMs are a semi-quantitative type of cognitive map that represent a system composed of relevant factors and weighted links showing the strength and direction of cause-effects relationships among factors. Therefore, FCMs can be interpreted as complex system structures or complex networks. In this sense, recent research has applied complex network concepts for the analysis of FCMs that represent social-ecological systems. Key to FCM the tool is its potential to allow feedback loops and to include stakeholder knowledge in the construction of the tool. Also, previous research has demonstrated their potential to represent system dynamics and simulate the effects of changes in the system, such as policy interventions.

For illustrating this analysis, we have developed a series of participatory FCM for the study of the ecological and human systems related to biodiversity conservation in two case studies of the Amazonian region, the Bolivia lowlands of Guarayos and the Brazil Tapajos National forest. The research is carried out in the context of the EU project ROBIN[1] and it is based on the development of a series of stakeholder workshops to analyze the current state of the socio-ecological environment in the Amazonian forest, reflecting conflicts and challenges for biodiversity conservation and human development. Stakeholders included all relevant actors in the local case studies, namely farmers, environmental groups, producer organizations, local and provincial authorities and scientists. In both case studies we illustrate the use of complex networks concepts, such as the adjacency matrix and centrality properties (e.g.: centrality, page-rank, betweenness centrality).

Different measures of network centrality evidence that deforestation and loss of biodiversity are the most relevant factors in the FCM of the two case studies analyzed. In both cases agricultural expansion emerges as a key driver of deforestation. The lack of policy coordination and a weak implementation and enforcement are also highly influential factors. The analysis of the system's dynamics suggest that in the case of Bolivia forest fires and deforestation are likely to continue in the immediate future as illegal activities are maintained and poverty increases. In the case of Brazil a decrease in available viable economic activities is driving further deforestation and ecosystem services loss. Overall, the research evidences how using FCMs together with complex network analysis can support policy development by identifying key elements and processes upon which policy makers and institutions can take action.

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