

## **How to cope with Global Change ? On the potential of ecological-economic modelling for institutional design**

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**Introduction** Ensuring sustainability in face of the multitude of ongoing processes of Global Change (e.g. climate change, land use change, social change, institutional change) represents one of the grand challenges of the future. This is especially urgent in the context of rangeland management in semi-arid regions. Strategies and policies are needed that allow coping with the impacts of Global Change on rangelands such as the increasing scarcity and variability in the precipitation, population growth, or globalization. The development of such strategies, however, requires insight into the relationship between institutional settings, management decisions and the long-term ecological-economic effects on the rangeland induced and into the impacts of the processes of Global Change on the functioning of the overall system. With such a dynamic understanding, key factors of sustainability can be determined and conclusions regarding the design of appropriate institutional settings for rangeland management can be drawn. The paper aims to demonstrate that ecological-economic modelling is a powerful approach to contribute to the development of sustainable solutions.

**Methods and material** We present an ecological-economic model that combines an ecological model for the rangeland dynamics (climate, vegetation, livestock, management system) with an economic model for the decision process in dependence on the ecological and socioeconomic conditions on the rangeland. This model provides insight into the interplay between ecological and socioeconomic factors and its effect on the rangeland dynamics and on several ecological and economic criteria of sustainability. Moreover, several scenarios (climatic conditions; vegetation types, population density; resource accessibility regimes) are considered and assessed in terms of their effects.

**Results and discussion** Starting point of the analysis is question of the relevance of temporal "resting" for the sustainability of rangelands. Using the model, it is shown that its relevance depends on two things: the vegetation type and the climatic conditions. The relevance increases with decreasing vegetation growth as well as with decreasing mean or increasing variance in the precipitation. In these cases, temporal resting is essential for the regeneration of the entire system. This indicates that climate change can alter the relevance of resting. It also clarifies that ensuring mobility is only one side of the sustainability coin; ensuring resting can be as important. By taking this finding as a basis, several consequences of population growth on the rangeland management and its sustainability are discussed. The necessity of ensuring temporal rests in spite of population growth (causing increasing pressure on the rangeland) indicates the importance of appropriate forms of co-ordinated rangeland management. Using the model, different forms of co-ordination are assessed in terms of their effects on sustainability.

**Conclusions** The model analyses reveal that climate change and population growth can alter the entire dynamics of the social-ecological rangeland system and, in the result, the requirements on both the management system and the institutional settings governing rangeland management decisions. This means that they can drive institutional change. As resting has been found to be an ecological-economic buffer mechanism and a key factor of sustainability, it can be used as a yardstick for assessing the appropriateness of existing institutions (Do they support or impede resting?). This particularly includes assessments of the relevance of elements of traditional forms of rangeland management. Because of its explicit ecological-economic structure, the presented modelling approach provides insight into the interplay and combined effects of various processes of Global Change and their long-term consequences for sustainability. Based on this, critical trends but also options for designing institutions for fostering sustainability can be identified.

### **References**

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