Land Use Policy 54 (2016) 47–57

Contents lists available at ScienceDirect

Land Use Policy

journal homepage: www.elsevier.com/locate/landusepol

Governmental response to climate risk: Model-based assessment of livestock supplementation in drylands

Jule Schulze*, Karin Frank, Birgit Müller

Helmholtz Centre for Environmental Research—UFZ, Department of Ecological Modelling, Permoser Str. 15, 04318 Leipzig, Germany

ARTICLE INFO

Article history:
Received 23 March 2015
Received in revised form
15 December 2015
Accepted 22 January 2016
Available online 12 February 2016

Keywords:
Sustainability
Subsidy programs
Risk-coping strategies
Pasture
Grazing
Drought

ABSTRACT

Drylands cover 40% of the world's surface and provide the basis for the livelihoods of at least one billion people. Pastoralists in these regions face risk and uncertainty due to highly variable climatic conditions. Therefore, and due to global change, novel risk-coping management strategies have evolved in recent decades. For example, in many pastoral regions in drylands government supplementary feeding programs are commonly introduced as a strategy to address multiple societal challenges related to climate risks, such as poverty alleviation or the maintenance of resilient pastures, in a cost-efficient way. Therefore, it is crucial to assess government supplementation programs from a multi-criteria cost-benefit perspective.

Using a generic, ecological–economic simulation model we analyze the potential benefits and threats of supplementary feeding in the form of government subsidies. Our results show that currently practiced supplementary feeding strategies may cause damage in the long term because of unintended side-effects such as degradation and cost explosion. In addition, we present a novel risk-coping strategy that supports farmers and is also both ecologically and economically sustainable. Last but not least, it is shown that government supplementation programs are only cost-efficient if they are regionalized and adapted to the specific ecological characteristics of the rangeland utilization systems in question.

1. Introduction

Drylands cover 40% of the world's surface and provide the basis for the livelihoods of at least one billion people (UNCCD, 2010). Pastoral systems are of particular importance in these regions as precipitation is scarce and highly variable, making crop farming difficult. Pastoralism describes a household strategy system where more than 50% of the gross revenue depends on livestock activities (Baumann, 2009). It forms a significant part of the national economies in developing countries (Davies et al., 2010) such as in Morocco where it contributes 25% to the agricultural GDP (Davies et al., 2010).

Dryland climatic conditions pose different challenges for pastoralists. Apart from facing income risks due to highly variable precipitation and drought, they are also faced with the danger of rangeland degradation and the income loss associated with it, which are potentially triggered by scarce precipitation and over-utilization of the rangeland and its natural resources (Sissoko et al., 2011). The estimated income loss due to rangeland degradation is $42 billion per year (UNCCD, 2010). Management strategies to cope with these challenges are needed to alleviate poverty and secure pastoralists' livelihoods while sustaining the ecological integrity of the rangeland.

Globally, various strategies are being used to cope with climate-related income risks and poverty. One recent approach involves providing pastoralists with financial support through government programs. Multiple novel governmental risk coping options have evolved. One example is the introduction of grazing reserves which famers can use in times of drought (FAO, 2010). This concept, based on the idea of mitigating degradation by regulating pasture access, is inspired by tradition, as these grazing reserves have existed already for a long time. Another strategy with a long history of use is destocking, which is based on the idea of managing the livestock to match fodder demand and supply. Under destocking programs, farmers are given incentives to sell livestock when natural fodder is scarce (FAO, 2010). In Kenya, for example, destocking programs were applied during the droughts in 1999 and 2000 (Aklilu and Wekesa, 2001). As a counterpart to these programs, restocking programs have been implemented to help farmers to recover their herd after a break-down caused by drought. One example of this kind of policy is the $330 million Reconstruction and Rehabilitation Programme for Agriculture and Rural Areas formulated by the Government of Bosnia and Herzegovina (IFAD, 1997, 1999).

* Corresponding author. Fax: +49 341 235 1473.
E-mail addresses: jule.schulze@ufz.de (J. Schulze), karin.frank@ufz.de (K. Frank), birgit.mueller@ufz.de (B. Müller).

http://dx.doi.org/10.1016/j.landusepol.2016.01.007
0264-8377/

Some governments also offer weather-based financial risk management instruments such as rain-index insurances (Müller et al., 2011) aimed at providing farmers with financial support in times of low precipitation. All of these government programs address multiple climate-related societal challenges such as poverty alleviation by enabling farmers to withstand times of crises, value addition and the maintenance of resilient pastures. Moreover, these goals have to be achieved in a cost-efficient way. But they also may cause unintended, unwanted side-effects that ought to be mitigated. For example, Carpenter et al. (2009) name the "dysfunction of institutions and policy" as one reason for degrading ecosystem services (Carpenter et al., 2009, p. 1306). To address these challenges, a comprehensive understanding of the long-term impacts of these programs on the social-ecological functioning and performance of pastoral systems is required.

This study focuses on a government risk-coping strategy of increasing global relevance: subsidized supplementary feeding in times of natural fodder shortage. Policymakers and development agencies have recently begun to include supplementation of livestock in their emergency programs, for instance in North Africa and West Asia (Hazell, 2000, p. 93), or as part of development projects (cf. the Project of Pastoral Development and Livestock in the Oriental PDPEO in Morocco, Mahdi (2007)). Under such programs, farmers receive supplementary fodder in order to maintain their livestock as the source of their livelihood. In Morocco, this approach showed some success: a drought in 1995 resulted in a cereal production decline of 17% of the preceding year, while livestock numbers were not much affected (Hazell et al., 2003). However, despite the positive effects of this form of drought relief, negative impacts may also result. Enabling the maintenance of high livestock numbers during droughts leads to increased grazing pressure which, in turn, is accompanied by an increasing risk of degradation. For example, in New Mexico, supplementary feeding resulted in 15–25% higher stocking rates than if the subsidies were not available to farmers (Hess and Holechek, 1995). This could lead to degradation in the long term, which would make the strategy ecologically unsustainable. This highlights the urgent need to reveal the factors determining the potential benefits and threats of supplementary feeding strategies. Müller et al. (2011) showed that an appropriate (rather low) frequency of payments reduces negative side-effects of rain-index insurances. We therefore hypothesize that the potential benefits and threats of a supplementation program are influenced by its specific design. In this study, we investigate the role of the way supplements are used (i.e., to avoid destocking or to rest the pasture) as well as the role of timing, intensity and frequency of supplementation. As cost-efficiency of the supplementation programs is of particular relevance for the government, tracking the costs as well as the benefits is crucial. For example, a drought in Tunisia 1988/89 resulted in coping costs of $82 million and of $30 million in Morocco in 1992 (Hazell, 2000). In our study, two different economic perspectives of assessment are incorporated—the perspective of the farmer (i.e., long-term income as well as income risk) as well as that of the government (i.e., net economic benefit of subsidy programs).

Several subsidy programs are based on traceable measures. For instance, under the already addressed rain-index insurances, farmers receive pre-specified payments when the current precipitation falls below a pre-specified threshold (Skees and Barnett, 1999). Such programs are advantageous due to their transparency and their simplicity with regard to monitoring (Miranda and Vedenov, 2001; Skees and Barnett, 1999). In a similar manner as rain-index insurances, the subsidy for supplementary fodder can be linked to a precipitation index. Therefore, in this study, we incorporate supplementary feeding strategies that are granted based on current precipitation levels and compare them to a strategy under which supplements are granted in times of need, irrespective of current precipitation.

The study also examines the extent to which the performance of a supplementation program is influenced by regional context, especially the biophysical conditions of the pastures and the ecological characteristics of the vegetation. Of particular interest here is the capability to build-up biomass reserves as a key mechanism for regeneration (buffer capacity), or population-dynamic characteristics of the livestock such as fecundity.

The main aim of this paper is to assess the cost-efficiency performance of government supplementary feeding programs in meeting multiple societal challenges: poverty alleviation, value addition and maintenance of resilient pasture. By using an ecological–economic simulation model and applying a cost-benefit approach, we evaluate two currently practiced and one newly designed supplementary feeding strategy from a multi-criteria perspective. The two currently practiced strategies are characterized by supplements granted in years of forage shortage and in drought years, respectively. Under these strategies supplementary feed is used to avoid destocking. The newly designed strategy supplements in droughts to avoid destocking and additionally in the year directly after a drought to rest the pasture. We analyze how potential benefits and threats of supplementation depend on both the specific design of the supplementation strategies and the characteristics of the regional context.

2. Methods

2.1. The model

Our model is a modified version of the generic, economic-ecological simulation model described in Müller et al. (2015). Here, we present a short description of the model. The full model description using the ODD (Overview, Design Concepts and Detail)—protocol (Grimm et al., 2006; Grimm et al., 2010) can be found in the Supplementary material A.

2.1.1. Purpose and basic idea of the model

The model was developed to analyze the ecological and economic implications of supplementation strategies in the form of subsidies provided by government agencies on a semi-arid rangeland system. The model is stylized and explicit in representing the main features of a semi-arid rangeland system, but is simple enough to demonstrate the consequences of different supplementation strategies (Schlüter et al., 2013).

For simplicity, we model one livestock-breeding household possessing one herd of sheep. The household depends exclusively on livestock production for its livelihood. It is assumed that no purchase of livestock takes place. Hence, herd growth is driven solely by birth processes. The interrelated processes between livestock and vegetation dynamics are simulated for a time horizon T of 60 years. The model runs in annual time steps.

The ecological model part of the stylized semi-arid rangeland corresponds to the ecological model described in Martin et al. (2014). As is common for semi-arid ecosystems (Linstädter and Baumann, 2013; Ruppert et al., 2012) the main driver of forage dynamics is annual precipitation r_t. The pasture is assumed to consist of an abstract perennial plant type (i.e., perennial grasses or shrubs), where all aboveground parts are accessible to small-stock. This perennial plant type is characterized by two functional parts: green G_t and reserve biomass R_t (Müller et al., 2007; Martin et al., 2014). The term green biomass refers to all photosynthetically active parts of aboveground biomass, which is assumed to constitute the main forage resource for livestock. Reserve biomass describes the non-photosynthetic reserve biomass (either below-