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Valuing ecosystem services to explore scenarios for adaptive spatial planning

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ABSTRACT

As the ecosystem services concept increasingly gains importance, it needs translation into practical applications. Recent efforts of EU member states to map ES are opening new opportunities to include ES in spatial planning and adaptive land management. For this, spatial planners and policy makers need practical tools that integrate a variety of social and biophysical information in an accessible way. We argue that monetary valuation of ES can contribute to this challenge. A methodological framework was developed to explore adaptive management of bioproductive space. The first stage in the methodology is a spatially explicit evaluation of various ecosystem services for different land uses. In a second stage, bio-physical and socio-economic drivers or shocks are introduced that can influence the value society attributes to specific ecosystem services. The third stage of the methodology takes policy priorities into account. In a final stage, the output of the approach is synthesised by ranking the analysis results for different scenarios and policy priority settings. This methodology allows spatial planners to explore and evaluate policy decisions against trade-offs between various land use alternatives, while taking ecosystem services into account. To demonstrate its use, the methodology is applied to a small-scale case study that combines extensive livestock production with the development of natural values. The application to the case demonstrates that the optimal strategy from a societal perspective, can be highly context-dependent. Besides the potential for supporting policy makers to think about the broader implications of land use changes for community wellbeing, the methodology provides useful feedback for adaptive farm and landscape management. We underline both the potential and possible caveats in using this approach for land use evaluation.

1. Introduction

1.1. Ecosystem services, land use change and spatial planning

Land is becoming an increasingly scarce resource, because of increasing population pressure and associated urbanization, coupled with the increasing demand for food and (bio)energy products (Meyfroidt et al., 2013; Tscharntke et al., 2012). This relative scarceness becomes more apparent with progressing insights that productive space worldwide delivers many functions and services (Lambin, 2012), expressed by a.o. the concept of ecosystem services (ES) (Millennium Ecosystem Assessment, 2005). Meanwhile, injudicious use of remaining space puts constraints on its provision of ecosystem services (Stoate et al., 2009). Like many urbanized regions in the world, urbanization in Flanders, the northern part of Belgium, leads to an increasing competition for the remaining open space (Kerselaers et al., 2013). This puts additional constraints to the delivery of ecosystem services by inhibiting more integrated, multifunctional forms of land use. This is particularly the case for the agricultural sector, which traditionally shows a clear emphasis on maximising provisioning ES, often at the expense of other services (Leinfelder, 2007).

The ecosystem service concept shows great potential to contribute to an adaptive spatial planning paradigm, combining robustness to develop ecosystem functions and services with flexibility to find new development paths to answer challenges (van Buuren et al., 2013). However, it is not yet a mainstream practice in spatial decision making. Adaptive planning assumes that complex processes are characterized by a large degree of uncertainty. Dealing with this requires room for experiment, monitoring and learning. While ES modelling tools are able to facilitate the practical application of ES in planning practices (Ruckelshaus et al., 2015), it remains a challenge to overcome static frameworks when it comes to foster adaptive planning and land management.

A promising approach is to combine (spatially explicit) quantifica-

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tion of ES with valuation techniques. A notable example on a larger scale is InVEST[1] (Integrated Valuation of Environmental Services and Tradeoffs), a collection of open source models for mapping and valuing ES (Sharp et al., 2015). At the very least, ES based decision tools should allow for the estimation of changes in ES delivery caused by land use and management changes (Bateman et al., 2014; Ruckelshaus et al., 2015). Furthermore, in the framework of the UK National Ecosystem Assessment, Bateman et al., 2014 emphasise the need to consider a broader ranges of both policy options and ecosystem services, while taking uncertainties in the valuation of the latter into account.

Here, we add to this by developing a framework that allows for exploring the performance of alternative land use options under various scenarios of shifting values attributed to ES. The framework presented here is developed to support decision makers to consider and integrate ecosystem services in land planning and management. In this paper, we explore a couple of land use alternatives that can be described as being active land management choices (e.g. choosing for organic or conventional production), but in practice, the analytical pathway can also be applied to modelled land use outcomes (e.g. under climate change). With respect to land use modelling, the approach recently published by Bateman et al. (2016) could prove to be complementary to our approach.

A practical application of ES in spatial planning is to evaluate land use alternatives over a whole range of ES. This should allow to choose for land use development pathways aiming at maximising the supply of ES. It is generally assumed that this results in more environmentally sustainable decision making. The added value of the ES concept is to come loose from a strict productivistic apprach, inspiring decision makers to take regulating and cultural ES into account as well.

The aim of this paper is to propose a conceptual framework to support scenario planning and foster adaptive decision making related to bioproductive space, with particular attention to food systems. We define 'bioproductive space' as all space providing ecosystem services through primary production processes in both (semi-)natural and agricultural ecosystems. These ecosystem services include food and biomass production, as well as regulating (e.g. climate regulation, pollination) and cultural (e.g. recreation, landscape amenity) services (Haines-Young and Potschin, 2010).

The framework is based on an appraisal of the ecosystem services provided by bioproductive space, irrespective of sectoral boundaries. This implies that agricultural areas can not only be seen as spaces for the production of food, fuel and fiber, but that associated non-provisioning ecosystem services are also to be recognized. On the other hand, there is potential for food and biomass production outside of the statutory agricultural area, for example on road verges, in natural areas and in residential gardens.

1.2. Drivers affecting food production systems in Flanders

Adaptation is meaningful only when described relative to a specific driver (Carpenter et al., 2001). Drivers generate shifts (slow) or shocks (fast), and can be of bio-physical or socio-economic nature (Fig. 1). A driver can cause a directional change to the social-ecological system. This in turn, influences the way land is used by that system. Examples of slow shifts are land speculation and privatisation, or ageing of the farmer population leading to farm size increase and the emergence of non-agricultural land use on farmland. Examples of faster shocks are exteme weather events, market price fluctuations or international conflicts.

As part of the Millennium Ecosystem Assessment (2005), Nelson et al. (2006) provide an overview of relevant direct and indirect drivers for global ecosystem change. Direct drivers cited are climate variability and change, drivers related to exploitation, land conversions, and

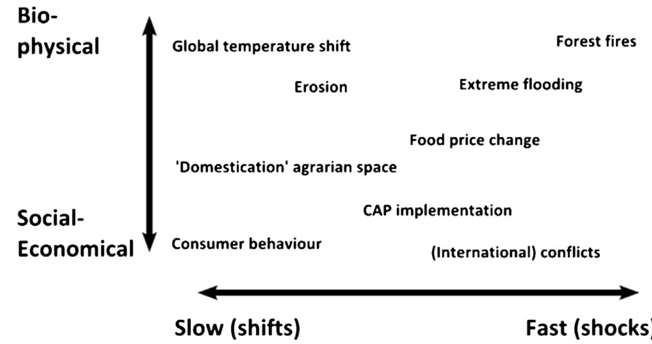

Fig. 1. Drivers that affect the food production system in Flanders, ordered according to their nature (from bio-physical to social-economical) and the speed upon which they act.

biological invasions and diseases. Indirect drives cited are demographics, economics, socio-politics, science and technology, and culture and religion. For Flanders, conversion of land from agricultural use into other uses is a relevant driver that is easily overlooked, because the total area of statutory agricultural land remained relatively constant during the last decades. Nonetheless, recent research points out that an estimated 10% of the agricultural land is used for non-agricultural purposes (Verhoeve et al., 2015). Land 'horsification', i.e. use for recreational horsekeeping is part of this driver (Bomans et al., 2010), as well as competition for hobby animal feed production (Van Gossum et al., 2014). These trends decrease the availability of land for agriculture both directly, by occupying land, and indirectly, e.g. by increasing land prices. This might limit the spatial adaptive capacity of the agricultural sector.

Also exploitation is considered a major driver in Flanders, with soil degradation, compaction and potential water shortage as major aspects (Van Gossum et al., 2014). Similarly, climate variability and change is an important driver. Although several benefits can be associated with climate change for Flemish food production, for most crop and livestock production systems a net productivity loss is expected, even when measures for adaptation are taken into account (Gobin et al., 2008). However, the relative productivity loss is expected to be less for agro-ecological production models, characterized by higher intrinsic tolerance levels to stress (Ulanowicz et al., 2009).

2. Study area and methods

2.1. Methodological framework for evaluating land use alternatives under changing societal preferences

In Fig. 2 we present the methodological framework in the form of a toolkit. For the purpose of clarity, we subdivided this framework in 4 distinct stages. On the input side is a spatially explicit analysis of the biophysical system and actual land use, as well as possible land use alternatives. This analysis should be sufficiently detailed to assess the delivery of ES by the land use alternatives. Since the EU calls its member states to map ES in the framework of Action 5 of the EU Biodiversity Strategy to 2020, there is an important momentum to use such spatially explicit datasets for land use evaluation.

In *Stage 1*, the differences in ecosystem services delivered by these alternatives in comparison to the actual land use are quantified and valued. This evaluation should be quantitiative and allow for aggregation of the ES, i.e. that different ecosystem services can be combined and compared. For this purpose, we use monetary valuation (in EUR). The differences in ecosystem service delivery are calculated between a baseline land use, in this case the actual land use, and a land use alternative. This can be seen as a basic outcome. In the following Stages, we tweak several methodological aspects and assumptions that we relied upon to reach this outcome. Each time we choose an array of simple tweaks, exploring the sensitivity of the approach for changes at

[1] available on www.naturalcapitalproject.org/invest.