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A modelling approach for the assessment of the effects of Common Agricultural Policy measures on farmland biodiversity in the EU27

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ABSTRACT

In this paper we describe a methodology to model the impacts of policy measures within the Common Agricultural Policy (CAP) on farm production, income and prices, and on farmland biodiversity. Two stylised scenarios are used to illustrate how the method works. The effects of CAP measures, such as subsidies and regulations, are calculated and translated into changes in land use and land-use intensity. These factors are then used to model biodiversity with a species-based indicator on a 1 km scale in the EU27. The Common Agricultural Policy Regionalised Impact Modelling System (CAPRI) is used to conduct the economic analysis and Dyna-CLUE (Conversion of Land Use and its Effects) is used to model land use changes. An indicator that expresses the relative species richness was used as the indicator for biodiversity in agricultural areas. The methodology is illustrated with a baseline scenario and two scenarios that include a specific policy. The strength of the methodology is that impacts of economic policy instruments can be linked to changes in agricultural production, prices and incomes, on the one hand, and to biodiversity effects, on the other – with land use and land-use intensity as the connecting drivers. The method provides an overall assessment, but for detailed impact assessment at landscape, farm or field level, additional analysis would be required.

1. Introduction

Within both natural areas and agricultural land of Europe biodiversity is declining. Agricultural land makes up about half of the land area of the European Union (EU27). Within agricultural land especially the traditionally managed lands are an important habitat for biodiversity (Donald et al., 2002). However, due to the conversion of natural grasslands into arable land over the last century, as well as the general intensification of agricultural practices over the last decades, farmland biodiversity has been declining. For example, the number of farmland birds in the EU has dropped by 15%–20% in the past two decades (PBL, 2012). The *EU Biodiversity strategy to 2020* (EC, 2011a) sets targets 'to halt the loss of biodiversity and the degradation of ecosystem services in the EU by 2020, restore them in so far as feasible, while stepping up the EU contribution to averting global biodiversity loss'. Farmland biodiversity is an important component of this strategy.

The maintenance and enhancement of farmland biodiversity increasingly depends on public intervention. The EU biodiversity strategy states that the forthcoming reform of the Common Agricultural Policy (CAP) presents opportunities to enhance synergies and maximise coherence with biodiversity objectives (EC, 2011a). One of the targets of the strategy is to maximise areas that are covered by biodiversity-related measures under the CAP, to ensure and improve the conservation status of species and habitats that depend on or are affected by agriculture, and to provide ecosystem services, thus contributing to sustainable agricultural management. In *The CAP towards 2020* (EC, 2010), the European Commission has outlined strategic options for greening of the CAP.

CAP instruments could stimulate farmers to undertake measures that are beneficial for biodiversity, but it is not clear how and where such measures should take place. Effective policy making is hampered, as the costs and quantity of biodiversity 'goods' – to be produced by farmers – and their linkages are not clear at the EU scale. Economic agricultural sector models exist for the calculation of the economic impacts of the CAP, but no satisfactory tools are available for the assessment of the influence of CAP measures on farmland biodiversity in the EU27. Many studies focused on the

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relationship between agricultural policy and biodiversity (e.g. Brady et al., 2009). However, impacts of greening the CAP on biodiversity in agricultural areas are often illustrated with case studies at local level (e.g. Poláková et al., 2011) and expert judgements at country or EU level (Butler et al., 2010). Integrated, quantitative modelling at EU scale is lacking.

This article focuses on integrated modelling of the impact of agricultural policies on biodiversity, agricultural production and farm income at EU27 level. The objective is to present the methodology and to illustrate the method with comparisons of stylised policy scenarios. The presented method consists of calculations with the Common Agricultural Policy Regionalised Impact Modelling System (CAPRI), which is a partial equilibrium model that has been widely used for economic scenario studies for the agricultural sector (Britz et al., 2012; Kempen et al., 2011), combined with a farmland biodiversity indicator for species richness in EU agricultural areas, developed by Overmars et al. (2013). These two elements are connected through the analysis and modelling of the land-use system and its intensity.

2. Methods

2.1. Overview

The objective of this study is to develop a modelling approach to systematically assess policy measures targeted at supporting biodiversity on farmland. We used a chain of models to describe the effects, from policy measure and economic effect through to land-use change and to biodiversity effects.

As an illustration, we identified two important policy measures from the proposed CAP (EC, 2010). These two measures, agri-environmental measures and ecological set-aside, could be easily incorporated in the CAPRI modelling framework. Crop diversification and maintenance of permanent grassland were more difficult to incorporate in CAPRI and were not included in this stage of indicator development and illustration. Since the proposed policy measures are described qualitatively, we quantified them into concrete scenarios. The scenarios include stylised, separate policy measures implemented in the same way in all regions and countries. This paper does not aim to assess the complete CAP reform for 2014–2020, since the aim is to describe the methodology and only to indicate what the effects of separate measures may be.

Fig. 1 presents a scheme of the models, and their inputs and outputs. The policy measures defined in the scenarios were implemented in the economic model CAPRI to calculate the effects on production, income, prices and land use and land-use intensity as indicated by the use of fertiliser and manure. In the next step, land use and land-use intensity from the CAPRI output were transformed into a format that would fit the subsequent part of the analysis. Crop-specific land use was aggregated to arable land and grassland. The N application to various crops computed in CAPRI, having an artificial intensive and extensive variant, was recalculated into areas of intensive and extensive management that link with absolute levels of inputs relevant to biodiversity, which are the same throughout the EU.

Using the spatially explicit land-use model Dyna-CLUE, the land-use areas determined regionally by CAPRI were allocated over Europe in a 1 km grid and these maps were, subsequently, classified into land-use-intensity classes. Farmland biodiversity is strongly related to land use and land-use intensity. Therefore, differences in land use and land-use intensity between the scenarios are important indicators of biodiversity change.

Since the effect on different farmland species differs by species and because the spatial distribution of species is heterogeneous we developed an indicator that is based on a number of species (Overmars et al., 2013). This indicator was used to translate the land use and land use intensity changes (and fragmentation) into a biodiversity effect.

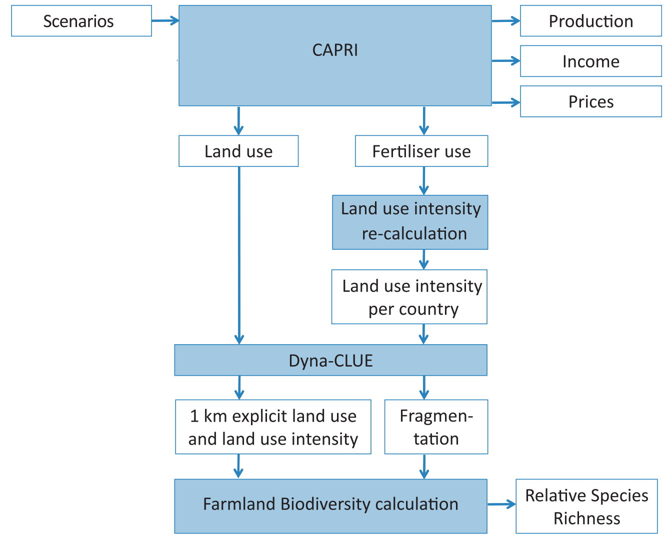

Fig. 1. Schematic representation of the methodology.

2.2. Model description

2.2.1. CAPRI

The first model in the modelling sequence is the economic model CAPRI. In this study CAPRI is the model where the policy scenarios are implemented.

The CAPRI model is an EU27 partial equilibrium model for the agricultural sector at NUTS2 level (aggregated regional farm approach). The model consists of a supply module and a global market model. The CAPRI supply module comprises 276 regional farm models: one farm model for each NUTS2 region in the EU27, Norway, Western Balkans and Turkey. The model covers 51 agricultural commodities in the market model. These are produced by about 50 crop and animal activities in each of the regions, using 9 general inputs, 3 crop-specific inputs, 6 intermediate crop outputs, 12 intermediate animal outputs, 3 types of mineral fertiliser and 10 tradable and non-tradable feed inputs. Each regional farm model optimises regional agricultural income at given prices and subsidies and is constrained by land availability, policy variables and feed and plant nutrient requirements in each region. Elasticities to calculate the parameters of the cost function per crop activity per region are derived from econometric estimates using the CAPRI database and model structure (Jansson and Heckelei, 2011).

The CAPRI global market model is a comparative static multi-commodity model, which covers 47 primary and secondary agricultural products (Britz and Witzke, 2011). The CAPRI supply module and global market model are iteratively linked. Equilibrium ensures cleared markets for products and young animals, and matches feed production with feed requirements of total animal stock at the national scale (www.capri-model.org).

Allocation of land to the various activities per region is steered by profit maximising behaviour of the regional farmer, in the supply part of the CAPRI model. If, compared to a calibrated baseline position, a land-based activity becomes more profitable through a policy intervention, the land allocated to this activity will increase, as will the marginal production costs (the costs of producing one unit of output extra). Within agricultural activities, there is a division into an extensive (low input, low yield) and an