Ecological Economics 123 (2016) 35–56

Contents lists available at ScienceDirect

Ecological Economics

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

Analysis

# Spatial impacts of the CAP post-2013 and climate change scenarios on agricultural intensification and environment in Austria

Mathias Kirchner *, Martin Schönhart, Erwin Schmid

*Institute for Sustainable Economic Development, University of Natural Resources and Life Sciences Vienna (BOKU), Feistmantelstraße 4, 1180, Vienna, Austria*

ARTICLE INFO

*Article history:*
Received 12 February 2015
Received in revised form 18 November 2015
Accepted 29 December 2015
Available online 27 January 2016

*Keywords:*
Agri-environmental program
Spatial targeting
Climate change impacts
CAP post-2013
Integrated analysis

ABSTRACT

We assess impacts of the latest CAP reform and regional climate change scenarios on agricultural land use intensification and environment in Austria for the period 2025–2040. A spatially explicit integrated assessment based on sequentially coupled models quantifies the impacts at a 1 km grid resolution in order to take into account the heterogeneity of agricultural production and environment. The CAP post-2013 will lead to a shift in direct payments from cropland to grassland dominated production regions as well as to a slight decrease in regional producer surpluses in Austria. The economic impact of climate change scenarios depends on the spatial location and the precipitation scenario. The CAP post-2013 will lead to intensification of agricultural land use in favorable cropland and grassland regions as well as to extensification in marginal areas. Regional climate change amplifies land use intensification with increases in crop and forage yields, e.g. in Alpine regions, and land use extensification with declining crop yields, e.g. in eastern cropland regions. Environmental indicators deteriorate at national level in all scenarios. Spatially highly diverging impacts call for more targeted policy measures.



## 1. Introduction

The early period of the Common Agricultural Policy (CAP) can be characterized by stimulating and modernizing agricultural production, and is thus seen as a major driving force of land use intensification in the past (Zanten et al., 2014). Reforms since the 1990s have focused on sustainable agricultural development (the implementation of pillar 2, i.e. the rural development program) by recognizing the multi-functional role of agriculture with respect to social and environmental aspects (Lowe et al., 2002). The success of these reforms with respect to environmental outcomes (e.g. biodiversity, landscape diversity, balanced supply of ecosystem services from agricultural landscapes), however, is controversially debated (Schmid et al., 2007; Stoate et al., 2001; Wier et al., 2002) and scholars are skeptical if the latest reform, CAP post-2013, will have substantial beneficial impacts on the environment and economic equity (Heinrich et al., 2013; Pe'er et al., 2014). Changes in the CAP post-2013 include the new 'greening' requirements for direct payments, a regionalization of remaining decoupled single farm payments in some countries, the abolishment of the milk quota, and changes in agri-environmental schemes.

Notably, these policy changes will be accompanied by climate change impacts. Agriculture is sensitive to climate change such that higher temperatures and $CO_2$ concentrations as well as changes in precipitation patterns and frequencies of extreme weather events have direct impacts on crop yields and agro-biophysical processes. These changes trigger farm management responses and alter environmental outcomes (Alexandrov et al., 2002; Olesen et al., 2011; BMLFUW, 2012; Mitter et al., 2014). Agricultural systems are highly dependent on the adaptation potential of farmers to alleviate negative or amplify positive impacts of climate change (Leclère et al., 2013; Schönhart et al., 2014). Regional climate change should thus be taken into account by policy makers and researchers, which has also been recognized by the new CAP regulations (The European Parliament and The Council of the European Union, 2013a, 2013b, 2013c). Hence, modeling the spatio-temporal impacts of policy and climate change on agriculture and environment allows providing reasonable policy recommendations beyond 2020.

Austria represents a good case study to assess both the impacts of the latest CAP reform and regional climate change. First, its agri-environmental program is covering about 87% of total agricultural land (excluding Alpine meadows), 77% of all farms, and comprises ca. 25% of all agricultural policy payments under pillars 1 and 2 of the CAP in the year 2013 (BMLFUW, 2014a). The proposed changes in agri-environmental payments and the renewed focus on pillar 1 payments thus likely have significant impacts on land use intensification in Austria. Second, climate change impacts in Austria can be substantial already until the mid of the 21st century and regionally heterogeneous due to its topography (Thaler et al., 2012; Strauss et al., 2013b; Mitter et al., 2014) and will differ largely in sign and magnitude across the agricultural landscapes and farming systems (Schönhart et al., 2014).

A few studies have already conducted ex-ante assessments of the CAP post-2013 reform, mostly with focus on the new greening

* Corresponding author.
*E-mail addresses:* mathias.kirchner@boku.ac.at (M. Kirchner), martin.schoenhart@boku.ac.at (M. Schönhart), erwin.schmid@boku.ac.at (E. Schmid).

http://dx.doi.org/10.1016/j.ecolecon.2015.12.009
0921-8009/

measures, i.e. (i) setting aside of 5% ecological focus area (EFA), (ii) crop diversification and (iii) maintaining existing permanent grassland. However, most studies do not consider climate change impacts. The qualitative studies conducted by Lefebvre et al. (2012) as well as Westhoek et al. (2012) find that the greening of pillar 1 payments is likely to have only limited effects on farming practices, agricultural landscapes, biodiversity and GHG emissions, whereby EFAs are expected to have the most pronounced effect. The impact of crop diversification is assumed to be insignificant as most farms in the EU27 would meet this criterion already today (European Commission, 2011a). Permanent grassland may be secured from conversion to cropland, but the final regulation (No. 1307/2013 Article 45/2), which had not been available to these studies yet, seems to differ little from the original cross-compliance requirement for permanent grassland maintenance in the period 2007–2013 (No. 796/2004 Article 3/2).[1] Van Zeijts et al. (2011) provide a detailed spatially explicit integrated assessment study for the EU27 on the CAP period 2014–2020 based on the EU communication document "The CAP towards 2020" (European Commission, 2010). They find that the pillar 1 greening measure reduces the decline in farmland biodiversity in the EU27 compared with a continuation of the CAP 2007–2013. GHG emissions decrease, but not significantly. Notably, the results of Van Zeijts et al. (2011) are strongly driven by the assumption that funding for agri-environmental measures does increase. This, however, is not indicated by the EU's final agreement on the multiannual financial framework for the period 2014–2020, where pre-allocations for the rural development program (i.e. pillar 2, see Regulation (EU) No. 1305/2013) are slightly below the pre-allocations for the period 2007–2013,[2] i.e. −1% and −2% for total EU payments and Austria, respectively. Regarding economic impacts, Solazzo et al. (2014) find that the two greening requirements crop diversification and EFA can lead to losses in gross margins for cropland farms and the tomato sector in Italy using a regional farm model. In contrast, van Zeijts et al. (2011) employ the partial equilibrium model CAPRI and find that average farm incomes in the EU can increase despite production decreases if commodity prices rise as a response. According to their results, farming incomes in Austria decline in cropland dominated production regions but increase in grassland areas in the Alpine regions. These model results indicate a shift of payments in the EU from intensive to extensive production regions, thus eventually providing a better link between payments and the provision of public goods such as biodiversity. In addition, Matthews et al. (2013) find that the transition of historical to regional area-based direct payments in Scotland shifts policy support from intensive to extensive production regions.[3]

Several integrated agronomic studies have already assessed the vulnerability of croplands to regional climate change in Austria until the mid of the 21st century (Alexandrov et al., 2002; Klik and Eitzinger, 2010; Thaler et al., 2012; Strauss et al., 2013b). Although these studies analyze and suggest alternative agronomic adaptation measures to reduce adverse impacts on crop yields and environment (e.g. soil conservation to reduce soil erosion and retain soil water content), they do not include any economic and policy aspects. Schönhart et al. (2014) show in a first national agricultural impact and adaptation study that autonomous adaptation by constrained profit-maximizing farmers can lead to positive economic outputs on average at the sector scale until the mid of the 21st century. They also reveal that economic and environmental impacts as well as the choice of adaptation measures differ substantially across NUTS3 regions in Austria. Given these regional differences, it is important to further analyze agricultural impact chains at finer spatial resolution as well as to evaluate trade-offs and synergies between economic and environmental effects from autonomous farm adaptation and agricultural policy reforms.

This article thus aims to quantify the impacts of CAP post-2013 and regional climate changes on agricultural intensification evaluated by a set of land use development indicators in Austria for the period 2025–2040. We apply a state-of-the-art spatially explicit integrated modeling framework assessment (e.g. Janssen et al., 2011; Laniak et al., 2013) in order to quantify both biophysical as well as economic impacts at a spatial resolution of 1 km. It comprises the statistical climate model ACLiReM (Strauss et al., 2013a), the agronomic crop rotation model CropRota (Schönhart et al., 2011b), the biophysical process simulation model EPIC (Izaurralde et al., 2006; Williams, 1995), and the bottom-up land use optimization model for the agricultural and forestry sector $PASMA_{[grid]}$ (Kirchner et al., 2015; Schmid et al., 2007). The article builds on the experiences of a previous analysis (Kirchner et al., 2015) in assessing the impacts of alternative policy pathways on the supply of ecosystem services. This study differs from the former in the following aspects: first, it explicitly considers the aggregate and spatial impacts of the latest CAP reform in Austria. Second, it introduces additional climate change adaptation measures such as reduced tillage and sowing of winter cover crops. Third, it provides more in-depth information on the bottom-up economic land use model for Austria, $PASMA_{[grid]}$, including a full mathematical formulation of the model, a thorough validation, uncertainty and sensitivity analyses. Providing transparency on data, assumptions, and model equations is crucial for building trust among scientists and stakeholders and to show that a model can investigate real-world problems in a state-of-the-art manner (Jakeman et al., 2006).

The remainder of the article is structured as follows: in Section 2, we introduce the methodological framework of our integrated assessment, provide detailed descriptions of $PASMA_{[grid]}$, model interfaces, major data sources, and model validation. Section 3 elaborates on the scenarios, Section 4 presents the scenario results and Section 5 investigates the sensitivity and uncertainty of commodity prices on model outputs. A critical discussion of our results and methodological approach is provided in Section 6. The article closes with concluding remarks and policy recommendations (Section 7).

## 2. Method

### 2.1. Integrated Assessment

The methodological framework of our integrated assessment (see Fig. 1) builds on the experiences and knowledge of previous model frameworks and applications (e.g. Kirchner et al., 2015; Kirchner and Schmid, 2013; Mitter et al., 2014; Schmidt et al., 2012; Schönhart et al., 2014, 2011a; Stürmer et al., 2013). It represents the most important driving factors and processes that affect land use change and management choices in agriculture as well as forestry.

In the framework, the CropRota model derives typical crop rotations at municipality level, taking into account observed land use and agronomic constraints (Schönhart et al., 2011b). The statistical climate model ACLiReM uses regressions and bootstrapping methods in order to forecast temperature trends and project precipitation patterns in Austria until 2040 (Strauss et al., 2013a). It provides physically consistent daily weather data at a spatial resolution of 1 km. Both models provide input to the biophysical process simulation model EPIC (Williams, 1995; Izaurralde et al., 2006), i.e. crop rotations and weather data respectively. EPIC simulates crop yields and environmental processes (e.g. evapotranspiration, mineralization, nitrification, and erosion) of alternative crop production management systems for different climate–site–soil–crop regimes at a spatial resolution of 1 km. Hence, outputs are differentiated by site-specific topographical, soil, and climate characteristics as well as by agronomic measures (e.g. crop

[1] For example, in regulation EC 769/2004 permanent grassland shall not decrease by 10% and in regulation EU 1307/2013 by 5%. In addition, a previous proposal by the European Commission (2011b) put the responsibility on farmers (Article 31/1) whereas in the final regulation EU 1307/2013 it is again the member state that is responsible for ensuring the maintenance of permanent grasslands.

[2] See http://ec.europa.eu/budget/biblio/documents/fin_fwk0713/fin_fwk0713_en.cfm#alloc.

[3] Van Zeijts et al. (2011) already consider the regional area-based payments in their baseline scenario. Their findings thus only relate to changes in the greening measures and agri-environmental schemes.