Farm-level land use strategies in terms of agricultural production and biodiversity conservation in Switzerland

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***Abstract* – Understanding farmers' land use behaviour is a pre-requisite for the design of effective policies aiming at protecting and enhancing biodiversity in agriculture. The aim of the present paper is to develop a typology of Swiss farmers' land use strategies in terms of agricultural production and biodiversity conservation. We adopt for that purpose a comprehensive perspective encompassing both the Ecological Focus Area (EFA) and the non-EFA. We use K-means cluster analysis to identify the farm types. We consider four clustering variables, namely the agricultural production intensity, the extent of farm's participation in agri-environmental schemes for biodiversity conservation and the impact of farm agricultural practices on the organismal biodiversity of the EFA and non-EFA. Our results reveal that land use strategies are not only heterogeneous but also complex, going beyond the classical myopic dichotomy of low *versus* high EFA share.**

INTRODUCTION

The exceptionally high species extinction rates observed in the last century and induced by the human domination of ecosystems suggest that a sixth mass extinction is under way (Ceballos et al., 2015). Biodiversity plays a major role in sustaining the productivity and stability of earth's ecosystems and thus human well-being (Cardinale et al., 2012). There is therefore an urgent need to reverse human-induced biodiversity loss (Shivanna, 2020). Agriculture is the main driver of biodiversity loss (Dudley and Alexander, 2017). As a response to growing concerns over the biodiversity loss caused by agriculture, agri-environmental policy instruments aiming at protecting and enhancing biodiversity were introduced in the 1990s in Switzerland. The most important instruments of the current Swiss agricultural policy for biodiversity conservation are the three cumulative area-based direct payments schemes for biodiversity conservation, namely the management-based Ecological Focus Area (EFA) payments, the result-based EFA bonus payments and the EFA-connectivity bonus payments (FOAG, 2020).

Understanding farmers' land use strategy is a pre-requisite for the design of effective policies aiming at protecting and enhancing biodiversity in agriculture. To the best of our knowledge, the existing socio-economic literature on farmer's biodiversity preservation and enhancement behaviour focuses mainly on the factors influencing the uptake of agri-environmental schemes for biodiversity conservation (see, for instance, Mack et al., 2020). Even if these investigations provide highly valuable insights into farmers' attitudes towards biodiversity conservation schemes, they present two shortcomings. First, by focusing on the EFA, these investigations ignore the remaining farmland (i.e., the non-EFA), which is also of importance in terms of biodiversity preservation, and thus neglect a part of the whole farm biodiversity picture. Secondly, in most of the existing studies, the success/effectiveness of agri-environmental schemes is assessed using indicators of their uptake. Uptake indicators may be particularly inappropriate for evaluating the effectiveness of management-oriented agri-environmental schemes because the link between land management and ecosystem services provision is rather weak and might lack scientific evidence (Rodríguez-Ortega et al., 2018). In the case of result-oriented schemes, uptake indicators may be relatively well appropriate for evaluating the scheme's effectiveness. One should however be aware that windfall effects might occur with this type of schemes (see, for instance, Fleury et al., 2015).

The aim of the present research is to provide a better understanding of the heterogeneity of land use strategies regarding agricultural production and biodiversity conservation in Swiss agriculture. We adopt for that purpose a comprehensive perspective embracing the whole farm, i.e., encompassing both EFA and non-EFA. We consider thereby not only the extent of participation in agri-environmental schemes for biodiversity conservation, but also the potential biodiversity outcome of farm practices on EFA and non-EFA as well as the farm agricultural production intensity. Our analysis based on a clustering procedure results in a typology of farm strategies regarding agricultural production and biodiversity conservation. We characterize the different farm types regarding their structural, managerial and socio-demographic characteristics as well as with respect to their natural environment (in terms of natural production conditions and biodiversity richness). We conclude on the implications of our findings in terms of an agri-environmental policy design.

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METHODS

Our investigation relies on unbalanced panel data from the Swiss Farm Agri-Environmental Data Network (FAEDN) for the years 2009 to 2018 (Stutz and Blaser, 2010). The sample consists of 2089 farm observations that were matched to the data of the Farm Accountancy Data Network (FADN). It covers the three agricultural regions (plain, hill and mountain) and all farm types as defined in Meier (2000) with the exception of farms with a strong focus on special crops. For the clustering, we consider four variables as described in Table 1 and use the K-means algorithm (see Hastie et al., 2009). To account for varying production conditions across the three agricultural regions, we cluster separately for each regional subsample.

Table 1. Variables used for the clustering

Variable	Description
EFA share in the UAA	Indicator of the extent of farm's participation in agri-environmental schemes for biodiversity conservation
Biodiversity score of the EFA	Potential impact of farm agricultural practices on the organismal (flora and fauna species) diversity of EFA assessed using the approach developed by Jeanneret et al. (2014)
Biodiversity score of the non-EFA	Potential impact of farm agricultural practices on the organismal (flora and fauna species) diversity of non-EFA assessed using the approach developed by Jeanneret et al. (2014)
Nitrogen output per ha UAA	Nitrogen output per ha UAA as an indicator of agricultural production intensity. It is derived from a soil-surface nitrogen balancing according to the approach described in Spiess (2010).

Meaning of the abbreviations: UAA = Utilised Agricultural Area; EFA = Ecological Focus Area

RESULTS

We find four clusters for the plain region and three clusters for the hill and mountain regions. The clusters are all characterised by very different farm strategies in terms of biodiversity conservation and agricultural production. Interestingly, there are strong similarities between clusters across the agricultural regions. In all regions, one cluster, called "the very intensive farms", shows a very high production intensity while the EFA share and the biodiversity scores of the EFA are relatively close to the regional average. This cluster exhibits in all three regions the lowest biodiversity scores of the non-EFA among all clusters. In the plain and hill region, another cluster, referred to as "the middle intensive farms with biodiversity-friendly practices", is characterised by an average or slightly below average production intensity and EFA share, but above average values for both biodiversity scores. These farms have a focus on dairy farming. A quite similar cluster can be found in the mountain region, where the better performance of this cluster in terms of the biodiversity score is restricted to the EFA. Finally, we identify a cluster, called "the specialized EFA producers", with a strong focus on cattle (especially beef) production, and also arable crops in the plain region. The farms of this cluster exhibit an extremely high EFA share while their biodiversity EFA score is among the lowest. The production intensity of this group is far below the respective regional average. The plain region consists of an additional cluster, called the "neither highly intensive nor particularly biodiversity-friendly plain farms with a high arable land share", capturing arable farming as well as dairy and cattle production. These farms show a below average production intensity, but also biodiversity scores (for both EFA and non-EFA) that are lower than the regional average. Only the EFA share of this cluster corresponds to the regional mean.

CONCLUSIONS

We conclude from the cluster analysis that land use strategies in terms of agricultural production and biodiversity conservation are not only heterogeneous but also complex, going beyond the classical myopic dichotomy of low versus high EFA share. We find that the highest EFA biodiversity scores were not necessarily observed in clusters with the highest EFA share. Besides, farms with a high production intensity may perform quite good in terms of EFA biodiversity score and even outperform the specialized EFA producers in this regard. The fact that the plain and hill clusters with the highest EFA and non-EFA biodiversity scores show an EFA share very close to the respective regional averages suggests that biodiversity conservation also takes place outside the EFA direct payment programs.

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