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The environmental sustainability of national cropping systems: From assessment to policy impact evaluation

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ABSTRACT

The European political framework of the last decade aims to drive agriculture towards economic and environmental sustainability. Thus, European institutions have paid great attention to environmental impact assessment and to the definition of a complex indicator capable of restoring the multidimensional nature of environmental sustainability.

In this work, a possible methodology for assessing the environmental sustainability of European national cropping systems by a synthetic indicator is provided. More specifically, the environmental impact of agriculture is assessed through a synthetic indicator, whose definition is based on a methodological improvement of the ecological footprint approach, which quantifies the balance between exploitation and availability of natural resources used in agriculture.

The analysis shows how national cropping systems can contribute to Europe's environmental impact through agriculture. To assess an eventual relationship between agriculture's environmental performance and the ability to support more sustainable agriculture at the national level, the results are then compared with the subsidies for agro-environmental measures provided by the second pillar of the CAP. In addition, the synthetic indicator chosen for the study, giving the possibility of quantifying the dynamic of the environmental impact of agriculture between two different periods, permits the analysis of the possible causes that may have generated the observed changes.

The implications of this approach should stimulate new reflections on the significance of the ecological relationships embodied into agricultural production and the environmental role of farmers.

1. Introduction

Agriculture, food production safety and natural resource preservation are all closely linked. Therefore, researchers and institutions are constantly looking for tools and policies that can lead to solutions that help ensure economic efficiency, social equity and environmental sustainability. The latter is mainly focused on climate change mitigation and adaptation, biodiversity, and water and soil preservation. Indeed, public and private stakeholders seem to highlight the wide role of farming in the preservation of natural capital.

Since the 1980s, this role has been recognized by the Common Agricultural Policy (CAP), which started to activate measures for improving the sustainability of European agriculture. At the beginning, the aim of the CAP was maintaining farm income and acting on internal market prices, subsides to export, and taxes on commodities imported. Throughout the years, the same policies have imposed the so-called "production quotas" and "set-aside measures". While these charges stemmed from what was discussed in the Uruguay Round GATT (rules with respect to the support of domestic agriculture), the "new" reasons to fund agriculture were based on environmental issues (Grossman, 2003; Berger et al., 2006).

In the 1990s, the CAP was radically changed, with subsidies no longer linked to production but assigned with respect to cultivated areas and farming management practices. At the same time, with the 1992 and 1999 reforms, the CAP was enriched with the instruments of rural development, pursuing synergistic environmental action through the Agri-Environmental Schemes (AES). From 1992–2002, approximately 25% of agricultural land in the EU was under AES agreements (Freibauer et al., 2004; Primdahl et al., 2010).

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Since their definition, AES were designed to ensure the protection, maintenance and enhancement of natural resources (water, soil, forests), biodiversity (species and habitat), and landscape. The AES payments are not directly related to the environmental performance but to the loss of income and/or the higher costs the farmer suffers as a result of the agri-environmental commitments that go beyond "good agricultural practice" (European Commission, 2005; Baylisa et al., 2008).

Since the Fischler CAP reform in 2003, the policy framework of environmental measures also included some mandatory constraints for farmers to fulfil in order to receive the direct payments provided by the CAP itself. The direct payments' cross-compliance, greening and AES are now integrated as tools that promote the sustainable management of natural resources by the primary sector. Although regulated by different policy mechanisms, the main objective of these tools is to increase the production of public goods, protection of the landscape, biodiversity conservation, adaptation and mitigation to climate change, availability and quality of water resources, and maintenance of soil fertility (European Commission).

This political framework aims to drive European agriculture towards economic and environmental sustainability (OECD, 2001; European Commission, 2006; OECD, 2008).

To define indicators able to test the effectiveness of the environmental measures still remains one of the Commission's main objectives, so the Commission-Eurostat, the Agriculture DG, the Environment DG, the Joint Research Centre and the European Environmental Agency (EEA) are all working on this topic. At the same time, researchers have proposed a wide range of indicators to assess the main environmental impact of the implementation of AES and the new greening payment tools.

Nevertheless, the voluntary environmental schemes proposed as part of the CAP and developed to answer to several and specific environmental issues, such as climate and sectorial structure (Keenleyside et al., 2011), are not standardized across European regions (Yli-Viikari et al., 2007). Thus, the CAP funds spent are not taken into account for their effectiveness as a result of a synergic action between economics and the environment but as a synthetic effort towards a general aim.

To link this gap, the strategic plan Europe 2020 integrates the concept of verifiability of environmental sustainability into the CAP policy (European Commission, 2006; Uthes and Matzdorf, 2013). Currently the European Commission proposes for AES evaluation a set of indicators to assess environmental topics both in the *ex-ante* (Common Context Indicators) and the *ex-post* (Target Indicators) analyses. This set, supported by national main statistics, will be used to evaluate each rural development plan.

Thus, the attention paid by European institutions to environmental impact assessment and the definition of a complex indicator capable of restoring the multidimensional nature of environmental sustainability (Gerdessen and Pascucci, 2013) is self-evident; such an indicator should give a clear picture of the environmental sustainability of agriculture in European countries and how it could be affected by sectorial policies (Collins and Fairchild, 2007).

This work, which is part of the above line of study, has a twofold purpose. The first is to present a possible methodology for assessing environmental sustainability, referring to the allocation among the different crops (crop mix) of the agricultural land in a country, of European "national cropping systems" with a synthetic indicator. The second objective is to use such a synthetic indicator to verify to what extent the CAP agri-environmental measures have increased the environmental performances of agriculture in different countries.

In the second section of the paper, the theoretical background of the so-called agriculture Ecological Balance indicator is described. This indicator, based on the general Ecological Footprint approach, seems to be able to assess the sustainability of agriculture by comparing its use/offer of natural resources. Indeed, farming activities, depending on bioclimatic zones and production techniques, can, at the same time, exploit and supply ecological services.

The third section presents the methodological approach adopted to evaluate the contribution of each European country cropping system to the environmental sustainability of European agriculture and to assess the possible effects of agri-environmental policies on the improvement of national cropping system sustainability. In this section, the datasets upon which the empirical analysis is based are also described, highlighting their characteristics and limits.

Finally, in the last section of the paper, the results obtained in the empirical analysis are presented and discussed.

The paper ends with some considerations about potentialities and limits of the proposed approach and possible suggestions for further research on this topic.

2. Assessing crops' environmental sustainability through the ecological footprint

The Ecological Footprint approach analyses the systemic interaction between the depletion and supply of natural resources. The depletion is measured through the ecological demand operated by humans and the supply through nature's ability to provide ecologic goods and services.

Introduced and developed by Rees and Wackernagel (1994) and Wackernagel and Rees (1996, 2008), the Ecological Footprint methodology provides a comparison between the natural capital consumption caused by human activities in a certain area and the ecological services that the natural ecosystems in the same area can provide.

More specifically, the Ecological Footprint indicator (EF) accounts for the demand of natural resource, while the Biocapacity indicator (BC) tracks the supply side and is evaluated considering the rate of resource regeneration and waste disposal that an area can sustain under the prevailing technology and management schemes. Both EF and BC are measured in a unit called global hectare (gha) that represents a standardized hectare with the world average productivity; it can also be thought of as a measure of the ecological productivity required to maintain a given product flow (Monfreda et al., 2004; Galli et al., 2007; Huijbregtsa et al., 2008).

The ecological footprint approach, because of its ability to assess an ecological balance between consumption and supply of natural resources, seems to be appropriate for evaluating the environmental sustainability of agriculture. Indeed, the definition of sustainable agriculture is concerned with the ability of agro-ecosystems to remain productive in the long-term and it implies the maintenance of the "natural capital" (the stock of ecological assets that provide a flow of useful goods or services) both as a "source" of inputs and as a "sink" for waste (Goodland, 1995).

Actually, in terms of sustainability, farming activities are mainly considered only from the point of view of their negative environmental impact (LCA analysis and greenhouse gasses emissions evaluation are two examples of such an approach). In this perspective, limiting the negative consequences of agricultural activities on ecosystems is the only effect of farmers' choices. In other words, farming activity is able to mitigate production impacts, ignoring its intrinsic capacity to provide ecosystem services.

The Ecological Footprint idea goes beyond this issue, taking into account resource exploitation due to farming choices (with the EF indicator) and the crop attitude into providing ecological services supply (with the BC indicator).

This possibility has induced many authors to adopt the Ecological Footprint methodology, improving and deepening specific