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*Editorial*

# Agro(Eco)System Services—Supply and Demand from Fields to Society

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Land use—with a special focus on agriculture—is increasingly influenced by globalization and external driving forces, causing farmers to seek opportunities to develop efficient, large-scale production systems. At the same time, specific markets are developing for high quality farm products or regional brands. The interest of agricultural producers to enhance production efficiency has often resulted in homogeneous landscapes with low structural diversity [1], soil erosion [2], high nutrient input and water pollution [3], resource-inefficient production schemes [4] and increasing dependence on subsidies, as well as losses in biodiversity and landscape aesthetics [5]. On the other hand, trends to counter these developments are emerging, focusing on natural capital and functions of landscapes and ecosystems other than production [6]. The situation is complicated by, for example, ongoing demand for renewable energy from biomass, continuing the pressure to maintain intensive land use systems [1,2]. Changes in established agricultural markets, climate change, globalization and demographic trends are thus influencing demands for agricultural goods and services. An essential question in this context is how society will be able to meet the multiple challenges of climate-friendly energy supply, food security and responsibly managing water and soil resources and biodiversity. Acquiring the knowledge needed to minimize conflicts between differing interests and related forms of land use is essential.

In spite of the importance of agricultural systems in providing vital resources, agricultural production is no longer the only dominant economic activity supporting rural economies. Rural development therefore needs to explore additional opportunities for the use of land, so as to contribute to maintaining economic activity in rural areas. Regions offering a wider range of goods and services may gain competitive advantages [5]. Thus, a cultural revalorization of regional agricultural systems is recommended [6]. Furthermore, safeguarding mechanisms are needed to ensure that farmers manage the land responsibly, taking into account the environmental effects agricultural activities generate. Negative effects could be compensated by the "polluter-pays principle" [5], whereas ecological-economic information could be used to support an ecosystem service-based management [3]. All these contributions are relevant to the discussion of ecosystem services provided by agricultural/rural areas and decision-making perspectives for managing them sustainably. Ecosystem services from agricultural systems pose a conceptual challenge, because agricultural systems depend heavily on human management activities. Benefits derived from these systems therefore cannot be assigned to ecological processes that exist independently of human activities. Agro(eco)system services need to be considered in the context of 'the multiple goods and services provided to humanity by nature' in combination with (often substantial) additional anthropogenic inputs [7] (such as fertilizer, pesticides, energy, labor, machinery, knowledge) [2–4,8,9]. Agricultural systems/landscapes are multifunctional; they supply visually distinct scenery, contain structurally and functionally distinct biodiversity, and they are the source for provisioning, regulating and cultural services [5]. Such landscapes are *per se* a result of particular demands for agro(eco)system services, and they have always been modified by human interventions into natural processes [6]. Applying the agro(eco)system services concept appropriately can help to show the effects of human interventions by qualitatively and quantitatively analyzing trade-offs between different ecosystem services [1,2,4–7] and by supporting the development of site-specific, more sustainable land use strategies. Within the political arena it may turn out that there might be a need to promote a new terminology, to talk about agrosystem services (*i.e.*, the anthropogenic contributions to ecosystem service generation in agricultural land use systems) and to strengthen the use of the term agro(eco)system services within this context.

In this Special Issue of LAND, existing agricultural systems in different socio-ecological settings are analyzed based on system-oriented modeling and simulation, experimental work, observations, interviews with experts, stakeholders and farmers, and analyses of agriculture and land use systems. Based on that, concepts for improved agricultural systems that aim to integrate the supply of/demand for multiple agro(eco)system services so as to maintain long-term ecosystem functioning are elaborated. The contributions include agro(eco)system service supply analyses (referring to food supply [1], fodder [4] biomass as a substitute for fossil resources [1,5], various regulating ecosystem services (2,3), cultural ecosystem services (ES) [1,2,6], and land use effects on biodiversity [1,2]. Table 1 gives an overview of the six different articles, the studied ecosystem services, whether trade-offs between different ecosystem services were analyzed as well as information about methods, scale and stakeholder involvement. Following the table, a short summary of the six individual contributions is provided.

**Table 1.** Overview of the articles in this Special Issue. Most of the studies (4) dealt with provisioning ecosystem services (ES), fewer with regulating ES (2) or cultural ES (3). All studies included a (in most cases regional) case study and involved stakeholders.

| Ref | Studied ES | Trade-Offs | Scenarios | Model | GIS | Case Study | Scale | Stakeholder Involvement |
|---|---|---|---|---|---|---|---|---|
| [1] | Bioenergy (S)<br>Food (S/D)<br>Landscape aesthetics (S)<br>Biodiversity | X | X | X | X | X | R | X |
| [2] | Agricultural crops (S)<br>C sequestration (S)<br>Water regulation (S)<br>Disease regulation (S)<br>Invasive species regul. (S)<br>Erosion regulation (S)<br>Symbolic interaction (S)<br>Biodiversity & habitat | X | X | | | X | R | X |
| [3] | Nutrient regulation (S) | | | X | | X | C | X |
| [4] | Fodder (S/D) | X | X | X | X | X | R | X |
| [5] | Bioenergy (S/D)<br>Multifunctionality | X | X | | | X | R | X |
| [6] | Recreation (S)<br>Spiritual values (S)<br>Aesthetic values (S)<br>Knowledge systems (S)<br>Cultural heritage (S)<br>Cultural identity | X | | X | | X | R | X |

ES = Ecosystem Services; S = Supply of ES; D = Demand for ES; GIS = Geographical Information System; R = Regional scale; C = Continental scale.

Scenarios of different intensities of maize production for bioenergy generation and related ecosystem services trade-offs were analyzed in [1]. The results of the GIS-based modeling study are useful for landscape planning and informed decision making. Land use change impacts on biodiversity and selected ecosystem services were mapped. Effects of different tillage/no-tillage agricultural practices on multiple ecosystem services were assessed based on expert interviews in [2]. Not only the results are of avail for understanding land management impacts, but the study process itself also contributed to awareness-raising, public involvement and the creation of collaborations between farmers, politicians and decision makers in the region.

Large-scale and long-term land-sea interactions related to eutrophication of the Baltic Sea due to agricultural nutrient inputs are the topic of [3]. Farm gate balances of nitrogen were analyzed and compared across different European countries based on different computer-based simulation, learning and planning tools. One solution to improve existing agricultural systems could be Ecological Recycling Agriculture (ERA) [3], which might be integrated in EU recommendations for organic farming. ERA could support a more resource-efficient agriculture and simultaneously reduce negative environmental effects. Agri-Environmental-Climate (AEC) payment schemes integrating also ES can be another approach towards a more environmentally-friendly agriculture [4]. Such schemes could for example be integrated into Rural Development Programmes (RDP) of the European Union's Common Agricultural Policy (CAP). The regional case study in [4] illustrates how model-based (ARIES model and GIS) scenario simulations in combination with existing data bases (such as the Farm Accounting Data Network FADN) can be applied to analyze and compare different agricultural management options.

Agriculture needs to be considered together with other human activities claiming land. A framework to assess the different demands for land use based on the Drivers-Pressure-State-Impact-Response (DPSIR) approach and the three pillar sustainability idea is presented in [5]. The concept can be used to identify ecosystem services trade-offs and synergies, land use conflicts and to develop recommendations for sustainable land use planning and decision making. Cultural ecosystem services and their interrelations with landscape conditions were the focus of [6]. Based on semi-structured interviews, perception studies and observations, a non-monetary evaluation of cultural ecosystem services in a traditional agricultural system was performed. The results can be used to reconsider human-environment interactions and the relevance of agriculture not only as producer of different provisioning ecosystem services, but also as contributor of non-tangible ecosystem services such as spiritual and aesthetic values, knowledge systems and cultural identity. Thus, inclusion of the agricultural sector into ecosystem service science–as practiced with this Special Issue–can accommodate the ecology-based ecosystem services concept to the specificity of managed agricultural ecosystems and therefore could be better implemented by mostly economy-driven agricultural production systems.

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