



## Review

## Comparative review of multifunctionality and ecosystem services in sustainable agriculture



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## ABSTRACT

Two scientific communities with broad interest in sustainable agriculture independently focus on multifunctional agriculture or ecosystem services. These communities have limited interaction and exchange, and each group faces research challenges according to independently operating paradigms. This paper presents a comparative review of published research in multifunctional agriculture and ecosystem services. The motivation for this work is to improve communication, integrate experimental approaches, and propose areas of consensus and dialog for the two communities. This extensive analysis of publication trends, ideologies, and approaches enables formulation of four main conclusions. First, the two communities are closely related through their use of the term “function.” However, multifunctional agriculture considers functions as agricultural activity outputs and prefers farm-centred approaches, whereas ecosystem services considers ecosystem functions in the provision of services and prefers service-centred approaches. Second, research approaches to common questions in these two communities share some similarities, and there would be great value in integrating these approaches. Third, the two communities have potential for dialog regarding the bundle of ecosystem services and the spectrum of multifunctional agriculture, or regarding land sharing and land sparing. Fourth, we propose an integrated conceptual framework that distinguishes six groups of ecosystem services and disservices in the agricultural landscape, and combines the concepts of multifunctional agriculture and ecosystem services. This integrated framework improves applications of multifunctional agriculture and ecosystem services for operational use. Future research should examine if the framework can be readily adapted for modelling specific problems in agricultural management.

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### 1. Introduction

Concerns regarding productivity-driven agricultural management intensified from the early 1970s due to its dramatic effects on environmental quality and rural vitality (Holdren and Ehrlich, 1974; Knickel, 1990). Researchers turned to traditional farming systems or new rural activities, such as farm-based tourism to explore

sustainable strategies (Gliessman et al., 1981; Evans and Ilbery, 1989; Altieri, 1992; Meeus, 1993). Multifunctional agriculture (MFA) and ecosystem services (ES) emerged from these pursuits, and have been considered, after being promoted by international programs, to be two important concepts for sustainable agricultural research and policy-making.

Agriculture is considered multifunctional when it has other additional functions to food and fibre production. The concept gained importance after being addressed in the Agenda 21 documents of the Rio Earth Summit (UNCED, 1992) with respect to sustainable development. It also was promoted by the European Union (EU) to justify agricultural supports in World Trade

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Organization (WTO) negotiations. The EU interpretation was normative, focusing on multiple roles assigned to agriculture by society (European Community, 1998). The Organisation for Economic Cooperation and Development (OECD) developed an analytical framework for MFA based primarily on a positive interpretation, considering agriculture as an economic activity that has multiple, interconnected outputs (OECD, 1998, 2001). This vision of MFA, combined with political demands for scientific output, stimulated many research programs (Laurent, 2002).

The concept of ecosystem services was introduced in 1981 (Ehrlich and Ehrlich, 1981) as a joint initiative of economists and ecologists. They emphasized that valuing nature's services in decision systems would correct misperceptions regarding the relationship between humans and nature. Costanza et al. (1997) defined ES as “the benefits human populations derive directly or indirectly from ecosystem functions,” and calculated the global value of ecosystem services from different ecosystems. This work is considered a milestone that mainstreamed the research. The United Nation's Millennium Ecosystem Assessment (MEA) program (MEA, 2003, 2005) greatly stimulated ES research and international projects, and firmly placed this concept in the policy agenda (Gómez-Baggethun et al., 2010).

MFA and ES were conceived during the same period, and had similar objectives to recognize agricultural benefits and impacts beyond the production of food and fibre. However, MFA and ES have progressed in different directions from similar origins. MFA horizontally enriched agricultural functions to include food security, environmental protection, and rural vitality, and MFA research investigates how these functions are jointly produced. ES vertically further developed the concept from “ecosystem functions” to “ecosystem services”, and pioneered strategies incorporating economic valuation and incentives (Haines-Young and Potschin, 2010). ES initially oriented toward natural ecosystems and blamed agricultural expansion for global ecosystem services damage (MEA, 2005). Subsequently, ES recognised agriculture as a provider and consumer of multiple ecosystem services (Swinton et al., 2007; Zhang et al., 2007).

Agriculture is a complicated socio-ecological system, posing many challenges to both MFA and ES communities. MFA must develop greater precision for the development of more effective policies (Garzon, 2005), whereas ES trends toward monetization and commodification should be carefully considered to avoid controversial outcomes (Gómez-Baggethun et al., 2010). Cooperation between the communities would be beneficial, particularly on common issues involving multidisciplinary approaches (Cowling et al., 2008; Renting et al., 2009). Effective communication between the communities is rare; some publications mention alternative concepts but rarely explore alternative approaches (e.g. MEA, 2005; Randall, 2007; Jordan and Warner, 2010).

The goal of this work is to provide a common platform for pooling and exchange of ideas and methodologies that could serve as a springboard to new levels of cooperation. We provide a comparative review of MFA and ES within the context of agricultural research. We address the following two specific objectives: first, we compare the ideologies and research approaches of MFA and ES; second, we propose dialogs and an integrated research framework that combine MFA and ES. Section 2 presents MFA and ES trends based on publication statistics (Section 2.1), compares the ideological bases of MFA and ES (Section 2.2), and compares MFA and ES research approaches for classification, valuation, trade-off, planning, and management (Section 2.3). Section 3 discusses possibilities for communication between MFA and ES communities by considering two specific questions, and proposes an integrated conceptual framework.

## 2. Literature review of multifunctional agriculture and ecosystem services

### 2.1. Publication statistics

Publication statistics were calculated to examine MFA and ES research trends. First, we identified all articles using MFA and ES that were indexed by Web of Science and published from 1975 to November 15, 2013. The search strategy for MFA included publications using the ideology of MFA in research on forestry (e.g., Brunet, 2007), prairie (e.g., Wiltshire et al., 2011), green infrastructure (e.g., Lovell and Taylor, 2013), land use (e.g., Wiggering et al., 2006), and landscapes (e.g., Jordan et al., 2011). The search strategy for ES included alternative names such as ecological services and environmental services (Lugo, 2008). Then, we identified publications involving agricultural problems, publications addressing multiple ecosystem services, and publications using both MFA and ES. Thus, we classified the publications into the following eight categories: MFA; ES; multiple ES; MFA and ES; and the subsets of the four preceding groups that specifically involved agriculture. Detailed explanations of the methods and figures are given in the online Appendix.

The results suggest that MFA and ES publications have similar global trends. They emerged in the 1980s, quietly incubated in the 1990s, and flourished in 2000s. MFA publications steadily increased from 2001, whereas ES publications increased explosively right after the end of the MEA program in 2005. The subsets of MFA and ES approaches that specifically address agricultural problems have less contrast regarding quantity than the total publications of MFA and ES. Publications on multiple ES appeared in 1992, and publication using both MFA and ES appeared in 1999. For publications addressing multiple functions or services involving agriculture, MFA publications started increasing earlier and grew faster than those of ES, but the latter show much stronger growth in recent years. Publications using both MFA and ES are a small proportion of the total (1.6% of ES publications and 13.8% of MFA publications). These results do not support the conclusions of Bonnal et al. (2012), who perceived trends of increasing ES use and declining MFA use. This is because ES engages in a broad range of subjects other than agriculture, and research can focus on a single ES. Without categorizing or specifying research topics (e.g., agriculture), the explosive increase of ES publications can give a false impression about MFA trends.

### 2.2. Ideological bases of MFA and ES

The ideas and concepts of MFA and ES do not originate independently. Their historical relationships are reflected in the evolving meaning bestowed on the term “function” in the two disciplines, which base their ideologies on the provision mechanisms of multifunctionality and ecosystem services. These basic distinctions largely influence the choice of scientific questions and methodologies, which are expressed as a preference for farm-centred approaches versus service-centred approaches, respectively.

#### 2.2.1. Historical use of the term “function” in MFA and ES

Early literature used the term “function” to refer to the provision of goods and services by the natural environment. For example, Holdren and Ehrlich (1974) used the term “public-service functions,” and de Groot (1987) proposed the concept of “environmental/natural function.” These publications demonstrate a common origin of MFA and ES. However, the ES scientific community considers that “function” more appropriately defines the ecosystem capacity to provide services (Haines-Young and

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