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Is it time for a socio-ecological revolution in agriculture?

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ABSTRACT

Sustainable intensification is touted as the future for agricultural land management in a world demanding greater food production. Agricultural practices remain primarily driven by the 'intensification' and not the 'sustainable' agenda. To turn this around requires clear evidence from ecologists about the nature of farming systems, the fundamental underpinning role of natural resources and ecological processes within them and the provision of feasible alternatives. Alternative ecologically based farming systems must reflect current wider food systems and the actors engaged in them with ecologists playing a key role in advocating change; from international global agreements which force political change, through changes in focus for agri-businesses, to decision-making by individual land owners.

1. Introduction

Over the past decade or more ecologists have engaged with both the ecosystem service (ES) agenda (MA, 2003; Zhang et al., 2007) and the need for developing sustainable agricultural systems (Firbank et al., 2013; Robertson and Swinton, 2005). The increasing numbers of publications concerned with 'food security' and 'sustainable intensification' in recent ecological journals reflect continuing concerns about the pressures of increasing food production on agro-ecosystems (Garnett et al., 2013; Letourneau and Bothwell, 2008; Swinton et al., 2007).

In the Green Revolution of the 1960's, ecological knowledge was used to revolutionise agricultural systems resulting in the dangerous contraction of the crop varieties used in agricultural production; the widespread use of fertilisers in response to their nutrient requirements and the use of pesticides, to reduce competition with other plants and limit the effects of herbivorous insects on those crops. Impacts on farming ecosystems were far reaching in both time and space, and highly damaging (Robertson and Swinton, 2005) as both the products themselves and the means of dispensing them began to dictate the farming landscape. What was missing from the processes which led to the drastic changes in farming was an evaluation of how these products would be used, their potential impacts beyond field scales and their wider impacts on society and ecosystems; the understanding that food production is part of a socio-ecological system. If we are to move towards more sustainable ecological practices in the future, we need to ensure that ecological knowledge is used within the wider context of the social-ecosystems in which 'agri' 'culture' is practised, so that we have a better understanding of, and more influence over how ecological innovation will change our world.

Whilst current food insecurity is a social issue, it will have devastating impacts on ecosystems if the ecological integrity of agricultural systems is not maintained. This paper presents the view that the time is right for ecological innovation in agricultural systems which promote sustainability of production, but advocates that we must innovate in close collaboration with all the other actors in current food systems in order to avoid perverse outcomes (Waterton et al., 2006) in other words, the food production and distribution network needs to be considered in its entirety.

2. Sustainable intensification

The term 'sustainable intensification' has been coined to encapsulate the need for increasing the intensification of management on agricultural land without further damaging ecosystems (Foresight, 2011; Tilman et al., 2011). For those in the business of agriculture the term provides validity for continuing current 'intensive' production practices (Petersen and Snapp, 2015), but encourages thinking around how these can be better maintained in the longer term (e.g. by improving land quality). For ecologists the emphasis is on 'sustainable' and the preference is for a term like 'ecological intensification' (Bommarco et al., 2013; Tittonell 2014) which provides a clearer understanding of the need for any intensification to be focused on enhancing the regulating and supporting services underlying agricultural systems. Such contrasting interpretations, and a lack of clarity

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and definition of the term across agronomic and ecological perspectives, as well as from a social perspective (Loos et al., 2014), are likely to have significant impacts on society's ability to achieve productive and sustainable farming systems into the future.

Another key issue is the starting point from which we propose to sustainably intensify production. In countries or areas where significant intensification has been taking place over decades the potential to provide more product out of ecologically impoverished land is far more challenging than in countries where land has never been intensively managed. From an ecological perspective the back drop of negligible improvements in yields in intensive systems in countries over recent years (Ray et al., 2013) infers a need for identifying new efficiencies which will better optimise ecosystem processes as part of the agricultural system (Smith et al., 2008). The will include factors such as the long term provision of nutrients as external input availability declines (Pretty, 2013) and optimising cropping options, both crop type and variety, to reflect ecological conditions both currently and under future climate change (Mathur, 2013). Getting land into good condition for appropriate crops for sustainable long term production should be the ecological focus. This may, however, result in a loss of production in the shorter term thereby requiring agricultural producers to focus on longer term production patterns.

2.1. The ecosystem approach

The ecosystem approach is one piloted by the Convention on Biological Diversity and forms the primary framework for action under the Convention. It is a strategy for the integrated management of land, water and living resources that promotes conservation and sustainable use in an equitable way (CBD, 2013). Recognising agriculture as a socio-ecological system i.e. a social system embedded in the natural environment, provides a good starting point for beginning to understand and influence the complexity of food systems (Fig. 1). Ecologically based research

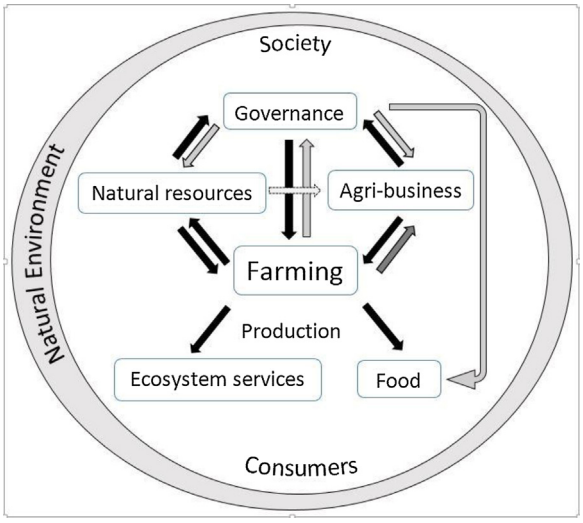

Fig. 1. A socio-ecological framing of food systems for agro-ecological science. Society/consumers drive the whole system which is in turn entirely dependent on the natural environment. Arrows indicate strength and direction of influences of different components on one another. Darker arrows indicate stronger influence. Connections between components and the relative strengths of those are clearly subject to interpretation.
Ecological science has a key role to play within the system in ensuring that natural capital and ecosystem processes continue to support a productive and sustainable agricultural system. **Ecological scientists** need to play a role in influencing government, farming and agri-business as well as broader society of the fundamental importance of ecology for future food production.

investigating potential long-term sustainable agricultural ecosystems (Bommarco et al., 2013; Firbank et al., 2013; Scherr and McNeely, 2008) recommends the integration of biodiversity based agricultural practices alongside more intensive management approaches, including: traditional farming, small holder enterprises, organic farming and agro-forestry (Cunningham et al., 2013; Firbank et al., 2013; Scherr and McNeely, 2008). Restoration of semi-natural habitats as part of a farming matrix, or a 'land-sparing' approach (Green et al., 2005; Phalan et al., 2011) may help to balance trade-offs between production, biodiversity and other ES, but such decisions need to be made at all scales from local to global (Cunningham et al., 2013; Swinton et al., 2007). Perverse outcomes may occur at national as well as at local scales, for example, from a global perspective, importing foods from other countries while reducing local (national) impacts on ecosystem services or biodiversity is only transferring the problem of agriculture's impact on wider ecosystems from one place to another. Similarly, intensification to ensure adequate food production may allow some land to be spared (Phalan et al., 2011) particularly in high output regions of the world, but will inevitably lead to high levels of inputs elsewhere (Pradhan et al., 2015) and their associated environmental problems, taking us back into the cycle of unsustainability that we currently occupy.

Farming sits at the hub of our food systems (Fig. 1). If scientists are to be involved in improving agro-ecosystems, it is essential for them to work alongside those managing the land (Cunningham et al., 2013; Dube et al., 2012; Robertson and Swinton, 2005; Scherr and McNeely, 2008; Zhang et al., 2007) and the food systems which rely on production (Loos et al., 2014). Integral to this is the need to incorporate social science which can help to improve our understandings of food producers and consumers and the political and economic systems of which we are a part, i.e. the 'cultural' parts of agriculture. Examples include understanding/land owner/land manager/farmer motivations and their cultural acceptance of agricultural practices and of the need to manage land for the production of ecosystem services (Burton and Paragahawewa, 2011; Greiner, 2015). Research investigating farmers responses to the 'food security' issue in the UK have shown that most of the (predominantly livestock) farmers interviewed believed that they needed to be part of an effort to increase food production and asserted the importance of reconciling this with wider sustainability (Fish et al., 2013). If new or, in some cases, revived practices are to be adopted there is likely to be a need to create social and cultural capital around the adoption of these practices, for example, certification based on product quality, breeding, good husbandry and land stewardship skills (Burton and Paragahawewa, 2011). An important and significant challenge in the developed world will be changing what have become the accepted 'norms' of modern agricultural practice (Fleury et al., 2015). Farmers have become accustomed to all-but eliminating non-crop species in pursuit of 'tidy' farms (Burton, 2012) and to farming monocultures of a restricted range of food crops. Encouraging farmers to adopt practices and cropping patterns which will see their farms transformed will take time, not least because of the need for acceptance within their peer group (See Koesling et al., 2012). Potentially the push will come from broadened dietary preferences or social desire for more diverse and complex landscapes.

2.2. Revolutionary ecological agricultural systems

What will the agricultural landscape look like if driven by ecological objectives of sustainable management? Research points to the prevalence of biodiversity based systems described above, alongside the use of traditional breeding, the re-development of locally suited varieties, intercropping, mixed farming systems, ensuring maximising nutrient and water use efficiency and the