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Review

Conceptualising fields of action for sustainable intensification – A systematic literature review and application to regional case studies

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ABSTRACT

After two decades of research on sustainable intensification (SI), namely securing food production on less environmental cost, heterogeneous understandings and perspectives prevail in a broad and partly fragmented scientific literature. Structuring and consolidating contributions to provide practice-oriented guidelines are lacking. The objectives of this study are to (1) comprehensively explore the academic SI literature, (2) propose an implementation-oriented conceptual framework, and (3) demonstrate its applicability for region-specific problem settings. In a systematic literature review of 349 papers covering the international literature of 20 years of SI research, we identified SI practices and analysed temporal, spatial and disciplinary trends and foci. Based on key SI practices, a conceptual framework was developed differentiating four fields of action from farm to regional and landscape scale and from land use to structural optimisation. Its applicability to derive region-specific SI solutions was successfully tested through stakeholder processes in four European case studies. Disciplinary boundaries and the separation of the temporal and spatial strands in the literature prevent a holistic address of SI. This leads to the dominance of research describing SI practices in isolation, mainly on the farm scale. Coordinated actions on the regional scale and the coupling of multiple practices are comparatively underrepresented. Results from the case studies demonstrate that implementation is extremely context-sensitive and thus crucially depends on the situational knowledge of farmers and stakeholders. Although, there is no 'one size fits all' solution, practitioners in all regions identified the need for integrated solutions and common action to implement suitable SI strategies at the regional landscape level and in local ecosystems.

1. Introduction

Responding to increasing global food demand, food production has kept pace so far through agricultural expansion and intensification (FAO, 2009; Tilman et al., 2011; Stevenson et al., 2013). Future prospects are, however, controversial. Whereas some estimate further increases in food production (Ewert et al., 2005), others assume stagnating or decreasing crop yields due to the limited and increasingly degraded land and natural resource base and impacts caused by climate change (FAO, 2009; Ray et al., 2012; Stevenson et al., 2013; Eitelberg et al., 2015).

Against this background, the notion of sustainable intensification of agriculture (SI) has received growing attention in its ambition to simultaneously tackle food security and environmental challenges. In the last two decades, SI research has shown manifold new paths on how to combine the maintenance or increase of agricultural production (Garnett et al., 2013; Röös et al., 2017) on the same area of land (Godfray et al., 2010) and the contribution to sustainable development in a balanced way (Gadanakis et al., 2015). However, with rising popularity, the scope and objectives of SI have been increasingly widened due to the variety of disciplinary perspectives, suggested SI practices and geographical foci of interest. SI embraces a broad range of practices and contexts, including smallholder agriculture in developing countries and agro-ecological principles as well as the application of new technologies and management styles (Baulcombe et al., 2009; Foresight, 2011). Further research foci have been set on technological advances

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and the assessment of SI from a global perspectives (Baulcombe et al., 2009; Tilman et al., 2011), the resilience and durability of production (Dile et al., 2013; The Montpellier Panel Report, 2013) as well as better knowledge of the production process (Buckwell et al., 2014). In line with these developments, SI has been connected to the provision of ecosystem services and economic, social and ethical aspects of sustainability (Barnes and Poole, 2012; Garnett and Godfray, 2012; Smith, 2013) or to the generation of multiple benefits. Godfray (2015) also highlight the role of SI for changing the food system as a whole, which includes questions of food supply chains, consumption patterns and food waste and losses.

Accordingly, controversies persist regarding the understanding of the scope and scale of sustainability or environmental goals (Buckwell et al., 2014; Petersen and Snapp, 2015), the extent of the environmental benefits generated, and negative effects mitigated (Pretty, 1997; Baulcombe et al., 2009; Garnett et al., 2013) or compensated elsewhere (Franks, 2014). The latter case even allows for intensification in some locations if associated negative impacts are counterbalanced by positive environmental impacts at another place. Given the need for action to simultaneously address issues of food security, increasingly limited natural resources (Cordell et al., 2009), environmental degradation (Smith et al., 2016), and climate change adaptation (Thornton and Herrero, 2015), more emphasis on the elemental principles of SI, namely the aspiration to increase food production on less environmental costs, is essential. Rather than a specific practice or set of practices, SI constitutes this aspiration as a goal (Garnett et al., 2013). Stronger orientation on implementation is needed, which in turn requires consideration of the regional and situational context, the selection and application of SI practices depends on (Godfray and Garnett, 2014). Therefore a clear and unbiased framework for the selection is required. In this regard, an acknowledgement and systematic structuring of the various ideas on SI implementation found in the scientific literature can support decision-making in practice and simultaneously contribute to a tangible conceptual understanding of SI.

Based on a systematic literature review, the objectives of this study are (1) to comprehensively explore the SI literature and provide a structured analysis of the diversity and scope of SI research and knowledge, (2) to propose an action-oriented conceptual framework on the basis of the portfolio of existing SI practices, and (3) to demonstrate its applicability to identify SI practices for region-specific problem settings in selected European case studies using a participatory stakeholder process. Findings concerning the three objectives are provided in separate sections (3–5), resulting in one proposition per objective, which are then resumed, discussed and connected in Section 6.

2. Methodology

We have carried out a systematic review of the existing literature in the field of sustainable intensification to obtain an interdisciplinary and comprehensive overview of the topic (von Döhren and Haase, 2015; Gao et al., 2017). Subsequently, we intertwined the review with the development of a conceptual framework of SI practices. First, the materials for analysis were selected by using the two main collections of academic literature, the Scopus database (www.scopus.com/) and Web of Science (https://webofknowledge.com/) (Aghaei Chadegani et al., 2013; Harzing and Alakangas, 2016). We applied the search term ‘sustainable intensification’ in title, author keywords or abstract for all research articles and review papers, which had been published before December 31st, 2016. In doing so, we deliberately captured only literature that focuses closely on SI. Our final database was composed of 349 papers. The overlap of the two sources of literature comprises 271 articles, 59 are exclusively collected by Scopus and 19 by Web of Science respectively. Each article’s meta data was recorded. This included the year of publication, keywords, the publishing journal, and both internal citations by other articles within our article sample (available for Scopus data only) and external citations in articles which are beyond this SI literature. We also included the geographic coverage for systematic analysis using information from abstracts and keyword search. All retrieved information was descriptively evaluated.

For a systematic description of the content of the selected papers, categories for analysis need to be defined in accordance with the research aim (Brewerton and Millward, 2001; Harkonen et al., 2015). In categorising, we addressed the practical implementation of SI in three taxonomic layers. The bottom is built by the concrete, practical actions an actor takes to implement SI which we collected from abstracts and conclusions of the articles. We refer to them as SI *practices* throughout the paper. Due to their diversity, the single SI practices are summarized in bundles of similar practices making up general SI *approaches*, our second taxonomic layer. As a third layer, four categories were derived from two discriminating dimensions namely spatial scale and activity scope of SI. The identified SI approaches were assigned to the categories named *fields of action* (FoA) for SI. They are the basis for a conceptual framework of SI. We collected 646 SI practices in the 349 articles which we summarized in 26 SI approaches. Although to some extent personal valuation guides assignment to the four FoA, the consistency of the final solution was verified by multiple rounds of cross-checks by researchers from different disciplines (incl. economics, geography, natural resource management, agricultural sciences). The final database is available through an additional data publication (Weltin et al., 2017).

The applicability of the framework to specific regional problem settings was tested in four regional European case studies through participatory processes with in total 68 stakeholders involved in land-use decisions (incl. agriculture, administration, environment, research). Case study regions were selected in order to capture a variety of geographical contexts, land use and landscape characteristics (van der Zanden et al., 2016). The participatory methodology was selected as a useful tool for the production of region-specific knowledge from the direct involvement of key stakeholders in the diagnosis of SI implementation (Kemmis et al., 2014). We drew on the methods of Reed et al. (2009) and started the fieldwork with in-depth interviews with farmers and other stakeholders relevant for implementing SI practices followed by a snowball sampling to identify the stakeholders that are part of each agrarian system. The second phase of the analysis was the organisation of a participatory workshop in the four European case studies. Methodological guidelines were elaborated to ensure that the workshops enabled the cross-comparison of the results. The main objectives of the workshops were: (i) to present to the stakeholders the four FoA stemming from the SI conceptual framework, (ii) to discuss the SI practices that are currently applied, commonly categorising them into the four FoA; and (iii) to stimulate stakeholders to share their understanding of possible future SI practices for their region. Results on current and future SI practices were descriptively evaluated and compared across regions.

3. Scope of the SI literature

3.1. Development of the SI literature

Initially introduced by Pretty (1997), the SI literature can be divided into three phases reflected by the temporal and geographical development of publications (Fig. 1). It originated in parallel to the mainstreaming of sustainability initialised by the Brundtland Report (1987) and the rise of the ecosystem service concept (Costanza et al., 1997; Daily, 1997), bringing environmental emancipation into the economic domain (Goodland and Daly, 1996). In a first phase (1997–2008), SI evolved to mainly explore the possibilities to support smallholder agriculture and livelihoods in Africa, Asia and Latin America while generating environmental benefits (Clay et al., 1998; Shiferaw and Holden, 1998). Research in this phase focussed on the improvement of underutilised land, the role of local knowledge and embeddedness in local social networks and institutions (Bebbington, 1997; Pretty, 1997). The first three years resembled a kick-off for SI research with 11