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Editorial: Breathing new life into farming: illuminating the socio-ecological benefits of regenerative agriculture

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Editorial on the Research Topic
Breathing new life into farming: illuminating the socio-ecological benefits of regenerative agriculture

Regenerative agriculture is a form of farming that seeks to conserve (or "regenerate") biodiversity and soil health while producing nutritious food, profitably (Rodale, 1983; LaCanne and Lundgren, 2018). It involves practices that intend to increase soil organic matter and carbon sequestration, reduce soil erosion and nutrient runoff, enhance soil fertility, and restore (functional) biodiversity and regulating ecosystem services (Sherwood and Uphoff, 2000; Schreefel et al., 2020; Giller et al., 2021). While the concept primarily aims to improve ecosystem health, it has the potential to address social inequity and to ameliorate the overall resilience of rural communities (Anderson and Rivera-Ferre, 2021) in line with the agroecological movement (Wezel et al., 2009). By fortifying a bundle of ecosystem services, regenerative forms of agriculture may deliver tangible benefits to farmers, consumers, agri-food businesses and the environment, while upholding societal wellbeing during times of unprecedented global change.

Despite a growing interest in regenerative agriculture among the world's farmers, land managers, and grassroots organizations, the term continues to be ill-defined and its broad societal benefits are insufficiently recognized. For instance, the impacts of regenerative agriculture on social inequity are still poorly addressed. This Research Topic offers greater clarity and consistency in applying and assessing regenerative agriculture practices, particularly as they relate to environmental and other social benefits in diverse farming systems. It investigates how established regenerative farms contribute to key ecological and socio-cultural ecosystem services and profitability across diverse farming systems. Eventually, it can facilitate the development of more effective and targeted strategies to promote agroecological and biodiversity-based farming.

Newton et al. characterize the term "regenerative agriculture" in an extensive review of 229 journal articles and 25 practitioner websites. They show that regenerative agriculture is defined through outcomes, as well as through processes, or practices, among which are reducing or eliminating tillage, crop diversification, ecological infrastructures (e.g., hedgerows, flower strips, beetle banks), agroforestry tactics or enhanced landscape complexity, reduction of synthetic inputs, and a (re)integration of crop and livestock production systems. Hence, regenerative agriculture emphasizes the smart use of natural functionalities (i.e., supporting and regulating ecosystem services) and ecological processes to create more resilient and sustainable agroecosystems. While equity and social wellbeing are cornerstones of agroecology (Altieri, 1999; Dumont et al., 2016; Barrios et al., 2020), regenerative agriculture primarily emphasizes soil health and biodiversity across journal articles and practitioner websites. Though its social benefits are undoubtedly tangible, they have largely remained occluded.

To optimally capture the biodiversity benefits of regenerative agriculture as compared to conventional farming practice, García-Vega et al. present the "agricultural boundaries for biodiversity" framework. Through an extensive literature review, they quantify the critical boundaries below or above which negative impacts are minimized or positive effects arise. Boundaries are proposed for 11 key biodiversity pressures and determinants, among which are agricultural areas, pesticide pollution, GHG emission, N and P runoffs, and semi-natural habitats within croplands. Importantly, they argue that, when implemented simultaneously, these boundaries would integrate biodiversity conservation within and across farmlands and minimize the environmental footprint of agriculture, *in fine* reconciling food production and biodiversity conservation at large scales. Looking forward, Garcia-Vega et al. highlight that the regenerative movement should focus on the simultaneous integration of multiple practices that promote biodiversity to enhance its benefits.

Linking theory and practice, Fenster et al. evaluate the impacts of regenerative farming on economic and ecological indicators in US almond orchards. Practices included abandoning some or all synthetic agrichemicals, planting perennial ground covers, integrating livestock, maintaining non-crop habitat, and using compost. Regenerative farming significantly improved soil quality [soil carbon, organic matter, and nutrients (N, P, Ca, S)] and water infiltration, increased biomass of microorganisms, and benefited plants (biomass, species diversity, and percent cover) and invertebrates (richness and diversity). Although almond pests, yields, and nutrient density were similar in the two systems, profit was twice as high in the regenerative orchards relative to their conventional counterparts.

Alexanderson et al. explore what regenerative agriculture represents for Australian farmers. An online questionnaire answered by 96 self-identifying regenerative farmers highlights the four main priorities of regenerative agriculture: 1. health of soils; 2. biodiversity, including microbiology; 3. water retention in soils and landscapes; 4. a holistic management approach. These priority thrusts are then expected to spawn tangible benefits in soil health, farm resilience, landscape health and profitability. Interestingly, time and financial resource requirements, knowledge needs and institutional support, specifically about reducing synthetic inputs, are perceived as key obstacles in the transition toward regenerative agriculture. This echoes the general challenges of adopting agroecological practices when the dominant agricultural model is locked in a socio-technical system that is highly reliant upon external inputs (Magrini et al., 2019).

Melo et al. analyze the strategies to transition from an input-intensive to a biodiversity-based agriculture. They use the Efficiency-Substitution-Redesign framework (Hill and MacRae, 1995) to methodically characterize the research geared toward management of the globally invasive fall armyworm, *Spodoptera frugiperda* (Lepidoptera: Noctuidae). Through a corpus of 1923 publications, they show that almost half of studies explore (single-factor) substitution solutions, i.e. the replacement of synthetic chemical inputs with more environmentally benign alternatives such as biological control agents or biopesticides. Meanwhile, the radical, wholesale redesign of farming systems is a domain that remains virtually unexplored and covered in merely 2.7 % of studies. Overall, the authors argue that scientists routinely fail to adopt the holistic approach as advocated by regenerative farmers (Wyckhuys et al., 2023) and fail to pursue "deep sustainability". They call for profound changes to the scientific enterprise and the funding models that are needed to support the transformation of present-day farming systems (Wyckhuys and Hadi, 2023; Han et al., 2024).

The present Research Topic contributes to filling several research gaps related to regenerative agriculture. It shows that its research is intrinsically holistic and interdisciplinary, offering fertile ground for a closer cooperation with the agroecological movement. Integrative 'systems' approaches are key to move this practice forward: Fenster et al. for instance illuminate how no one single practice is responsible for the success of regenerative farms. Their overall success and biodiversity benefits hinge upon the simultaneous integration of multiple regenerative practices into a single, functional farm system. By doing so, one can secure an effective delivery of multiple ecosystem services and, ultimately, achieve desirable social-ecological outcomes at the farm level (González-Chang et al., 2020; Hatt and Döring, 2023). Transformative in essence, regenerative agriculture poses a powerful pathway to improve the socio-ecological benefits of farming, as long as this concept is not coopted and/or greenwashed for other political and economic agendas (Wilson et al., 2024).

Author contributions

SH: Writing – original draft, Writing – review & editing. IA: Writing – review & editing. JL: Writing – review & editing. KW: Writing – review & editing.

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KW was employed by Chrysalis Consulting.

The remaining authors declare that the research was conducted in the absence of any commercial or financial relationships that could be construed as a potential conflict of interest.

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