Regenerative agriculture-agroecology without politics?

Pablo Tittonell, Veronica El Mujtar, Georges Felix, Yodit Kebede, Luciana Laborda, Raquel Luján Soto, Joris de Vente

frontiers | Frontiers in Sustainable Food Systems

TYPE Opinion
PUBLISHED 02 August 2022
DOI 10.3389/fsufs.2022.844261

OPEN ACCESS

EDITED BY
Erin Silva,
University of Wisconsin-Madison,
United States

REVIEWED BY
Jonathan Lundgren,
Ecdysis Foundation, United States
Timothy Crews,
The Land Institute, United States

*CORRESPONDENCE
Pablo Tittonell
p.a.tittonell@rug.nl

SPECIALTY SECTION
This article was submitted to Agroecology and Ecosystem Services, a section of the journal Frontiers in Sustainable Food Systems

RECEIVED 27 December 2021
ACCEPTED 07 July 2022
PUBLISHED 02 August 2022

CITATION
Tittonell P, El Mujtar V, Felix G, Kebede Y, Laborda L, Luján Soto R and de Vente J (2022) Regenerative agriculture—agroecology without politics?
Front. Sustain. Food Syst. 6:844261.
doi: 10.3389/fsufs.2022.844261

Regenerative agriculture—agroecology without politics?

Pablo Tittonell[1,2,3]*, Veronica El Mujtar[1], Georges Felix[4], Yodit Kebede[5], Luciana Laborda[1], Raquel Luján Soto[6,7] and Joris de Vente[6]

[1]Agroecology, Environment and Systems Group, Instituto de Investigaciones Forestales y Agropecuarias de Bariloche (IFAB), INTA-CONICET, San Carlos de Bariloche, Argentina, [2]Agroécologie et Intensification Durable (AïDA), Centre de Coopération Internationale en Recherche Agronomique pour le Développement (CIRAD), Université de Montpellier, Montpellier, France, [3]Groningen Institute of Evolutionary Life Sciences, Groningen University, Groningen, Netherlands, [4]Centre for Agroecology, Water and Resilience, Coventry University, Coventry, United Kingdom, [5]Eco&Sols, Université de Montpellier, IRD, CIRAD, INRAE, Institut Agro, Montpellier, France, [6]Soil and Water Conservation Research Group, Spanish Research Council (CEBAS-CSIC), Murcia, Spain, [7]Agroecology, Food Sovereignty and Commons Research Team, University of Córdoba, Córdoba, Spain

KEYWORDS

soil restoration, resilience, sustainability, climate change, agroecological transition

Introduction

Regenerative agriculture is gaining momentum worldwide among practitioners, scientists and policy makers, and it is often associated with agroecology. Indeed, regenerative agriculture has plenty in common with agroecology: e.g., soil and ecosystem restoration, reliance on biological interactions and ecosystem services, integration of domestic plants and animals, efficient use of the photosynthetic potential of annual and perennial combinations (Luján Soto et al., 2020; Schreefel et al., 2020; Giller et al., 2021). One aspect of agroecology that does not always fit comfortably in the realm of regenerative agriculture is political activism, or the place and emphasis that the "social" dimension takes in the definition of the social-ecological system. This is perhaps one of the reasons why agroecology is more closely associated with peasant movements, for whom claims on rights and access to natural resources are urgent (e.g., Rosset and Altieri, 2017), while regenerative agriculture is an approach increasingly—but not exclusively—also adopted by commercial, often large-scale farmers or external investors less concerned with natural resource access or food sovereignty issues. Thus, while the agroecology movement sees sustainability first and foremost as a political issue, regenerative agriculture seems *a priori* to be less concerned with politics and with the social dimension of sustainability. Yet, our first-hand experience in the field tells us that there may be more than one "type" of regenerative agriculture, that vary in their degree of association with agroecology. We find it timely to explore the diversity of definitions of regenerative agriculture available and their relationship with the most widely accepted definition of agroecology (cf. FAO, 2019).

Regenerative agriculture, agroecology, conservation farming, organic agriculture, etc. can be all seen as means to achieve a similar yet vaguely defined goal: sustainable agriculture. Simply defined, sustainability is the ability to meet the needs of the present without diminishing the ability to meet the needs of the future. Proponents of regenerative agriculture, however, aim beyond sustainability, that is, to contribute to constantly improving the environment (e.g., Ikerd, 2021) and farmland economic viability (Elevitch et al., 2018). This narrative was coined by Robert Rodale in the 1980's, the first one to propose regenerative *organic* agriculture (ROA) as an approach "beyond sustainable." Although the term organic seems to have been lost along the way, the Rodale Institute is still promoting ROA, around which they even built an international certification system that considers social values such as worker well-being (https://regenorganic.org). The "regenerative" narrative has become increasingly attractive, especially after the evident failure of the UN Sustainable Intensification discourse at engaging supporters amongst environmentally mindful stakeholders (Struik and Kuyper, 2017). However, vague and diverse definitions, lack of regulation and protection of the term, leads to a situation in which governmental agencies, industries and sector organizations have their own interpretation of regenerative agriculture, depending on particular interests. It has even been pointed as a green washing strategy of governments and large multinational companies, a fact that is raising increasing criticism and concern (see later, Box 3). The arrival of these newcomers is not necessarily a reason for joy amongst regenerative agriculture organizations, particularly those that explicitly oppose the use of chemical inputs such as pesticides or mineral fertilizers (Schreefel et al., 2020).

Regenerative agriculture definitions allow for such diversity of interpretations because they are often based on practices (e.g., by General Mills Inc.: no-tillage, soil cover, crop rotations), and less often on principles (e.g., by Terra Genesis International: ensure reciprocal relationships, design and decide holistically, improve whole agroecosystems, continually grow and evolve). Alternatively, certain organizations define regenerative agriculture in terms of processes and outcomes, or a combination of the two (Newton et al., 2020). Outcome-based definitions may however imply some flexibility in terms of the processes that lead to those outcomes, and their possible collateral effects. The ROA approach referred to above, on the other hand, places emphasis on processes (closed nutrient loops, diverse biological communities, fewer annual and more perennial plants, reliance on internal rather than external resources) to define regenerative agriculture. Removing the term "organic" from the definition of regenerative agriculture allowed, on the one hand, to increase the adherence to the concept without having to comply with the more rigid regulations of organic farming. On the other hand, however, it opened the door to the potential use of the term regenerative agriculture for green-washing agricultural practices that are irreversibly tied to agrochemical inputs.

Agroecology offers principles and processes, not prescriptions, for the transformation of the global food system based on participation, localness, fairness, and justice that "is not only sustainable, but also helps restore and protect Earth's life support systems for all people and future generations" (cf. Gliessman and Tittonell, 2015). Regenerative processes, in the sense of regenerating ecosystems and their social fabric, are already implied in such a definition of agroecology. A wide diversity of world organizations convened during several symposia organized by the UN Food and Agriculture Organization (FAO), between 2013 and 2018, proposed a working definition of agroecology based on ten elements that combine social and ecological principles (FAO, 2019; Barrios et al., 2020). The ten elements represent principles operating at both farm and community level (Figure 1), and are the backbone of the TAPE indicator framework (Tool for Agroecological Performance Evaluation—Mottet et al., 2021). Responsible governance, human and social values, circular and solidarity economy and resilience are key elements of agroecology that pertain to the political sphere, in the sense that they could hardly be achieved without engaging politics and policies.

Why focus on regenerative agriculture?

Arguably, most of the recent approaches to sustainable agriculture, be them conservation farming, climate smart agriculture, nature-positive farming, etc., lack an explicit socio-political dimension. If the lack of a socio-political dimension is not only inherent to regenerative agriculture (RA), then why focus on it? Here are a few reasons:

1. RA is gaining momentum across different contexts and sectors, partly due to its attractive name to which people can immediately associate a positive narrative;
2. The question arises frequently in different settings as to what is the actual difference between RA and agroecology (to the point that many take them to be synonyms);
3. In our practice, we do observe that RA and agroecology are overlapping to variable degrees, ranging from cases in which RA includes all 10 elements of agroecology, to those in which RA is just a term used to "re-pack" conventional agricultural practices.

We aim to highlight and explore such nuances, now that RA is influencing the international agendas. This article examines (i) the literature—both grey and published—to explore conceptual and practical similarities and differences between regenerative agriculture and agroecology, and (ii) a few examples from practice, relying on first-hand engagement of the authors in both agroecology and regenerative farming approaches in

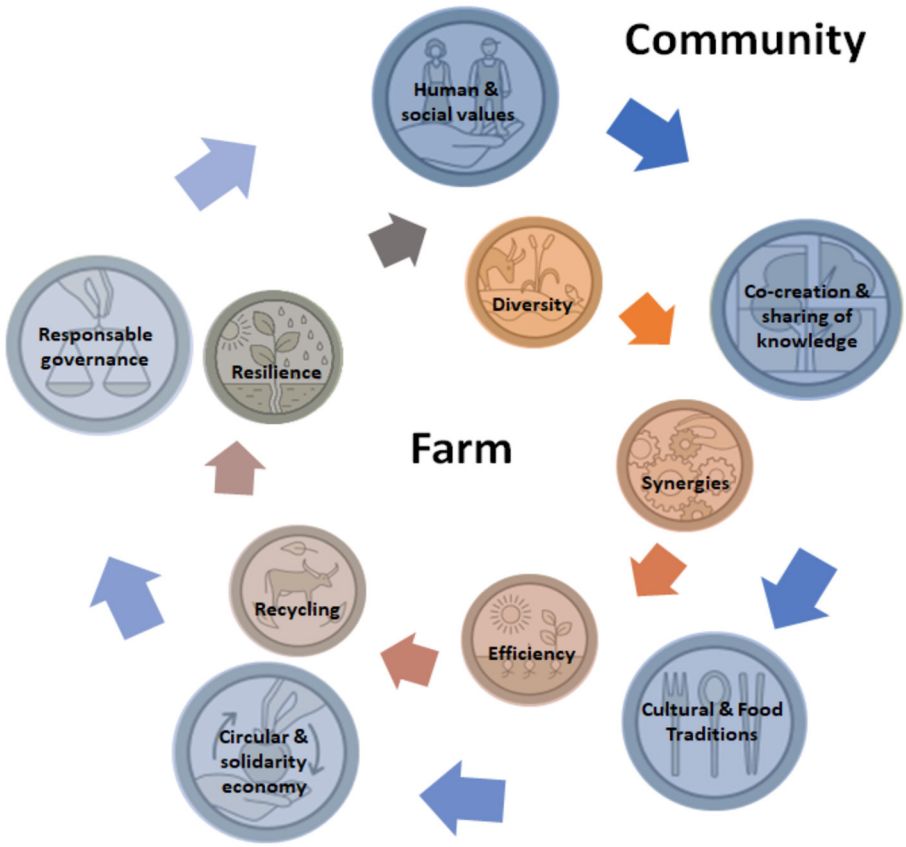

FIGURE 1
The 10 elements that define agroecology, used in the TAPE framework, represented as those that operate mainly at farm (grey-orange) or mainly at community (blue) level. Principles such as resilience, recycling or synergies operate also at community level, but they are assessed using farm-level indicators within the TAPE framework.

different parts of the world. As internet remains the main source of information on RA, accessed by practitioners, policy makers and scientists through search engines, we examined the 10-top internet hits that result from typing "Regenerative agriculture" in Google. We performed this search from different geographic locations (see author's affiliations). The objective of our analysis of the scarce scientific literature, case studies and internet sources is to help better define the term RA, explore the diversity of RA approaches and their relation with agroecology, and highlight the crucial role of politics and the social dimension to achieve actual implementation of sustainable farming practices and sustainable development of socio-ecosystems.

Regenerative agriculture concepts and terminology

During the last decade, regenerative agriculture has gained increasing attention in the scientific literature (Rhodes, 2017; Elevitch et al., 2018; LaCanne and Lundgren, 2018; Newton et al., 2020; White, 2020; Day and Cramer, 2021; Giller et al., 2021; Green et al., 2021; McLennon et al., 2021—see: Figure A in Supplementary Material I) but still lacks a comprehensive scientific definition. In their review, Schreefel et al. (2020) noticed both divergence and convergence among the various definitions in the literature, particularly on the explicit adoption or not of organic agriculture principles (e.g., Malik and Verma, 2014 vs. Elevitch et al., 2018). When discussions about a RA definition involve other groups of actors as well, e.g., governmental agencies, sectoral organizations, industries and farmers, each of these groups may propose different definitions dependent on their particular interests. In this section, we first scan the internet (websites and grey literature reports) to illustrate the diversity of RA definitions that pop-up as first hits, as proposed by different types of organizations. Then, we perform a systematic search of the scientific literature and analyse their content based on co-occurrence of terms and concepts.

A diversity of RA definitions

Regenerative agriculture (RA) refers to agricultural practices that regenerate soils, natural resources, landscapes and ecosystems. The term was coined by Gabel (1979) and, as explained earlier, it was later articulated by Rodale (1983) in the definition of ROA. The publication of Francis et al. (1986) is perhaps the first one that mentions the potential for RA in the developing world. However, the term has resurged in the last decade and gained momentum worldwide across academics, NGOs, farmer unions and international companies. It is not our intention to propose a definition of RA here, particularly when a large number of articles are being published nowadays on the subject. Here we focus on the concepts used to define RA, be them principles, practices, or outcomes. When it comes to current definitions of RA, there seems to be as many as there are organizations working on RA worldwide. To arrive at the non-exhaustive examples we reproduce here, we performed internet searches on regenerative agriculture using the Google search engine. To minimise regional biases, we conducted the searches from The Netherlands, France, UK, Kenya, Puerto Rico, Spain and Argentina. We selected the organizations/definitions that came consistently on top of the lists in all searches (we skipped Wikipedia). For example, a Google search on the term "Regenerative agriculture" in The Netherlands, results in the following top-10 sources[1]:

1. https://regenerationinternational.org
2. https://www.metabolic.nl
3. https://www.nrdc.org
4. https://ellenmacarthurfoundation.org
5. https://www.renature.co
6. https://www.unilever.com
7. https://www.earthday.org
8. https://www.nestle.com
9. https://www.cbf.org
10. https://www.cargill.com.

Such a list of internet hits, a combination of websites from NGOs and multinational food companies, is already quite illustrative of our earlier point: there is not one single "type" of regenerative agriculture, but a diversity of approaches and hence of definitions. The "Definition paper" that can be retrieved from the Regeneration International website (www.regenerationinternational.org), which is a co-production between the Regenerative Agriculture Initiative at California State University, Chico ("Sustainability at Chico State—CSU, Chico" n.d.) and The Carbon Underground (www.thecarbonunderground.org), defines RA as:

> *"Farming and grazing practices that reverse climate change by rebuilding soil organic matter and restoring degraded soil biodiversity—resulting in both carbon drawdown and improving the water cycle."*

And further, as:

> *"Holistic land management practice that leverages the power of photosynthesis in plants to close the carbon cycle, and build soil health, crop resilience and nutrient density"*

The permaculture organization Terra Genesis International proposes a working definition ("Regenerative Agriculture—The Definition of Regenerative Agriculture" n.d.) that is constantly upgraded by contributions from a worldwide RA community. They use four postulates to define RA, literally:

- RA is a system of farming principles and practices that increases biodiversity, enriches soils, improves watersheds, and enhances ecosystem services
- RA aims to capture carbon in soil and aboveground biomass, reversing current global trends of atmospheric accumulation
- RA offers at the same time increased yields, resilience to climate instability, and higher health and vitality for farming and ranching communities
- RA draws from decades of scientific and applied research by the global communities of organic farming, agroecology, holistic management, and agroforestry.

Most organizations, but not all of them, propose both *principles* and *practices* to define RA. In design, principles refer to the guiding truths or reasons behind practices. While principles are constant regardless of circumstances, practices are flexible and adaptable to varying circumstances. organizations working on RA then use principles as guidelines, as frameworks, and identify possible practices to implement such principles. For example, the company Danone promotes regenerative agriculture under three overarching principles: (i) protect the soil, (ii) empower a new generation of farmers, and (iii) respect animal welfare (https://www.danone.com/impact/planet/regenerative-agriculture.html).

The Regenerative Agriculture Initiative, referred to above, proposes the following RA principles (literally):

1. Contribute to generating/building soils and soil fertility and health;
2. Increase water percolation, water retention, and clean and safe water runoff;
3. Increase biodiversity and ecosystem health and resiliency; and
4. Reduce carbon emissions and promote significant carbon sequestration to cleanse the atmosphere of legacy levels of CO_2.

1 Revisited on 16 May 2022.

The four key words in this set of principles are soil, water, biodiversity and carbon. Expressed as such, these principles resemble practical objectives. Yet, this organization proposes also sets of practices to achieve these objectives (cf. Sustainability at Chico State—CSU, Chico n.d.).

Another example of practice-oriented principles is the "six core principles" defined by the multinational firm General Mills (see later, Box 3), which proposes to:

1. Understand the context of your farm operation
2. Minimise soil disturbance
3. Maximise crop diversity
4. Keep the soil covered
5. Maintain living roots year round
6. Integrate livestock.

Except for the last one, these practice-oriented principles refer mostly to annual cropping systems (e.g., maize, wheat, oats, etc.), which is not surprising, since most farmers working with General Mills are commercial large-scale cereal farmers. Further, General Mills measures the impact of RA by monitoring indicators across five goals, which are (i) economic resilience in farming communities, (ii) soil health, (iii) water, (iv) biodiversity, and (v) cow and herd wellbeing (in dairy operations). Comparing these against the principles of the Regenerative Agriculture Initiative illustrates how the same elements that are proposed as principles by one organization may be proposed as goals by another.

Another related approach, with more anchorage in the livestock ranching sector, is the so-called holistic grazing management ("Holistic Management International—Healthy Land, Healthy Food, Healthy Lives" n.d.), which aims to enhance the positive role that livestock can play in ecosystems *via* nutrient recycling, soil restoration and biodiversity conservation.

The permaculture network referred to above, Terra Genesis International, uses principles that are more generic, and hence probably more broadly applicable irrespective of context, scale or type of production system (literally):

1. Progressively improve whole agroecosystems (soil, water and biodiversity)
2. Create context-specific designs and make holistic decisions that express the essence of each farm
3. Ensure and develop just and reciprocal relationships amongst all stakeholders
4. Continually grow and evolve individuals, farms, and communities to express their innate potential.

These four statements read as principles, in the sense that they are generic and independent. However, to achieve these principles, Terra Genesis International enumerates a long series of RA "practices," as they call them, which are the same as those to be found on the Regeneration International webpage:

- No-till farming & pasture cropping
- Organic annual cropping
- Compost & compost tea
- Biochar & *terra preta*
- Holistically managed grazing
- Animal integration
- Ecological aquaculture
- Perennial crops
- Silvopasture
- Agroforestry.

What this list includes is actually a mixture of scientific disciplines, farming principles, movements and practices, and is so broad and diverse that it becomes confusing. While compost or biochar are practices or technologies, organic farming or ecological aquaculture are production systems (which may include compost or biochar). Perennial crops is too broad a category as it may include also industrially-managed fruit orchards. No-till farming and pasture cropping are management techniques, whereas agroforestry is both a type of production system and a scientific discipline. Except for organic annual cropping, the lists of practices of these different organizations do not explicitly mention the place that input based technologies such as chemical fertilizers and pesticides, or genetically modified crops, may have in the various RA approaches.

Instead of principles and practices, the Rodale Institute ROA approach proposes three pillars, which they integrated within the portfolio of more classical criteria used to certify organic farms, to create their Regenerative Organic Certification system (literally):

- Pillar 1—Soil Health: use of regenerative practices like cover crops, crop rotation, and conservation tillage. Builds organic matter and promotes biodiversity with no synthetic input (excludes soil-less systems such as rock wool substrates in greenhouse horticulture);
- Pillar 2—Animal Welfare: protects the Five Freedoms[2], grass-fed & pasture-raised, no concentrated animal feeding operations or extensive transport, suitable shelter;
- Pillar 3—Social Fairness: ensures fair payments and living wages for farmers and farmworkers, safe working conditions, capacity building and freedom of association.

There are, however, a few unifying principles that are consistent across virtually *all* RA proponents. They include, according to LaCanne and Lundgren (2018), the following ones:

1. Abandoning tillage or actively rebuilding soil communities following a tillage event;

2 Freedom from hunger and thirst; freedom from discomfort; freedom from pain, injury or disease; freedom to express normal behavior; freedom from fear and distress.

2. Eliminating spatial and temporal events of bare soil;
3. Fostering plant diversity on the farm; and
4. Integrating livestock and cropping operations on the land.

Although RA is often defined from an agronomic perspective, e.g., relying on the use of plant, soil, ecological and system knowledge to support the production of food, feed and fibre in a sustainable way, there are also those that take a more farmer-centred approach to define RA. An example is the Farmer-led Regenerative Design (Lunn-Rockliffe et al., 2020), which advocates that designing sustainable food systems must begin with farmers. Focusing mostly on smallholder family agriculture, the steps in the farmer-led regenerative design are:

1. Building a qualitative understanding of local farming livelihoods.
2. Co-designing a modular programme from the qualitative baseline.
3. Building an open access knowledge store.
4. Feed into a larger regional policy-led regenerative design.

The idea of scaling up a farmer-centred approach to regional designs brings us to the concept of landscape approaches. A landscape approach includes a "set of concepts, tools and methods deployed in a bid to achieve multiple economic, social and environmental objectives (multifunctionality) through processes that recognize, reconcile and synergize interests, attitudes and actions of multiple actors" (Campanhola et al., 2019). Landscape approaches include watershed management and restoration, forest conservation, water resource management, marine and coastal management and reversing land and soil degradation (e.g., Sayer et al., 2013). Most of these goals require community efforts, especially in the context of smallholder family agriculture; i.e., there is a limit to what a single farmer can do to restore an entire watershed.

A glance at the scientific literature

A systematic literature search in Scopus database recovered 645 articles that include "regenerative agriculture" (29 articles) or "agroecology" (616 articles) in the article title. Text mining of terms from "Title, Abstract and Keywords" of these articles (methodology described in Supplementary Material—II) revealed four classes of terms based on Reinert's top-down hierarchical classification (Figure 2A). Each class relates to a specific dimension, such as "knowledge" (Class 1), "framework and definitions" (Class 2), "social engagement" (Class 3), and "practices" (Class 4). More than 70% of the variability in the cloud of terms was explained by a *post-hoc* correspondence factor analysis (Figure 2B). Globally, the analyses showed that each class differs in the textual information provided. A detailed explanation of the methodology used in this section is provided as Supplementary Material (II).

Structural differences among classes were also evident based on a network analysis of the co-occurrence of terms in each class (Figure B in Supplementary Material). The co-occurrence network of Class 1 terms has four principal clusters that globally reveal the main focus of scientific research. The terms "research" and "agroecological" appeared as the main centroids, followed in relevance by "learn" and "education" in agroecology, and how the "knowledge" is generated in this discipline. The co-occurrence networks of Class 2 and Class 3 terms have in both cases unique clusters centred around the term "agroecology", and include terms associated with definitions and concepts inherent to the ecological aspects of the discipline (Class 2) and those associated with its social and political dimensions (Class 3). Minor clusters of this last network highlight the relevance of "food governance" and "food sovereignty" and of Latin American social movements. The co-occurrence network of Class 4 terms has four main clusters. The network is centred around the term "crop", which is connected with clusters centred in "soil", "management" and "farm" (both in the same cluster), and "agricultural". The term "Regenerative agriculture" appears in the soil cluster, highlighting its close association with soil quality improvement and conservation.

The co-occurrence network analysis based on the 29 articles that included "regenerative agriculture" in their title revealed four main clusters (Figure 3). The principal cluster (violet), centred around "regenerative agriculture", includes terms related to its definitions and concepts. The green cluster centred in "soil", one of the central goals of RA, reveals terms related to effects of RA on soil improvement, soil quality/health drivers, and other pivotal natural resources. The turquoise cluster includes terms related with food production, a second goal of RA. The orange cluster, including the terms evaluation, participatory and monitoring is perhaps the closest to what could be defined as a social dimension of RA. These observations correspond to a few articles from a PhD Thesis on "Participatory monitoring and evaluation of regenerative agriculture in South West Spain" [Luján Soto et al. (2021)—cf. Box 1].

The co-occurrence network analysis of terms based on keywords reported in 101 articles recovered from Scopus database including the term "regenerative agriculture" in title, abstract and keywords, revealed the connection of RA with other approaches (Figure 4A). The blue cluster is centred around regenerative agriculture, but also includes terms such as sustainable agriculture, organic agriculture, permaculture and holistic management. The yellow cluster reveals the connection of RA with agroecology, alternative agriculture, and soil quality. The green cluster is centred in agriculture and on its connection with soil (microbiology), environmental protection, and ecosystem. The red cluster links RA with agroforestry and holistic and strategic approaches, and highlights the relevance of land management and land use in nitrogen, carbon and

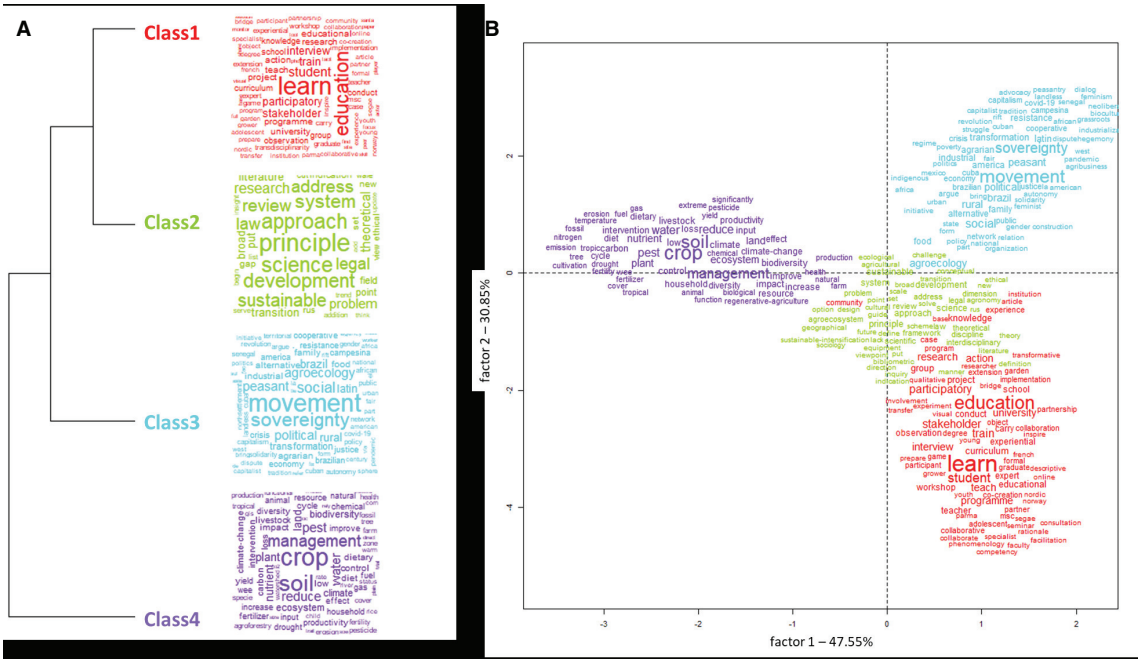

FIGURE 2
Reinert's top-down hierarchical classification ($N = 645$). **(A)** Dendrogram and word-cloud of each class, size of text is proportional to term's frequency; **(B)** *Post-hoc* correspondence factor analysis of term class, size of text is proportional to its Chi2 value and indicates the association strength with the class.

carbon sequestration, and in provision of ecosystem services. The violet cluster links RA to the food industry, food supply and sustainable development.

Finally, the co-occurrence network analysis based on keywords reported in 4426 articles recovered from Scopus database including the term "agroecology" in title, abstract and keywords, revealed four main clusters (Figure 4B). The blue cluster, centred on "agroecology," reveals its connection with the food system, food production, food sovereignty, food security, sustainable development, humans, social movements, etc. The green cluster highlights the relevance of "biodiversity" for agroecology, including ecosystem services. The red cluster groups terms related with crop production and yield, including soil and water management practices and main threats (e.g., climate change, fertilizer application) to natural resources. The yellow cluster includes terms related with the main crops and their associated microbiome. These four major clusters could be associated, respectively, with the social, ecological, agronomic and biological dimensions of agroecology.

Synthesising, the lexical analysis of the scientific literature revealed that agroecology and regenerative agriculture have several terms (notions) in common, confirming our empirical observations. The social dimension is poorly represented in regenerative agriculture, at least in the scientific articles that are published so far. Yet, this is a field of growing interest and likely to generate more and more diverse publications in the near future. The breadth of concepts and dimensions that were found in the literature search on agroecology reveals its interdisciplinary nature, and its intersection with many of the other approaches to sustainable farming that are proposed nowadays. Such an observation promoted us to postulate the hypothesis illustrated in Figure 5, which shows that agroecology has areas in common with all these approaches without being exactly the same. Besides, agroecology is also a social movement that counts thousands of adherents worldwide, from grassroots organizations to international NGOs, governmental agencies, national and international research and development organizations, branches of national governments, groups and programs at universities and research institutes, peasant movements, consumer organizations, indigenous peoples, etc., and has an explicit interest in transformational politics (Rosset and Altieri, 2017). The latter is perhaps the largest difference between agroecology and the rest of the approaches.

But agroecology is also a scientific discipline, which exists at least since the 1930s (e.g., Hanson, 1939) and provides the knowledge, principles and practices used by other approaches, such as climate-smart agriculture, conservation agriculture, nature-positive solutions or regenerative agriculture (the list may certainly continue, to include permaculture, organic farming, biodynamics, etc.). Given the overlap between regenerative agriculture and agroecology in several agronomic/ecological aspects (soil, microbiome, water, carbon), and their divergence in the social as well as other dimensions (e.g., pest and disease management), the following section

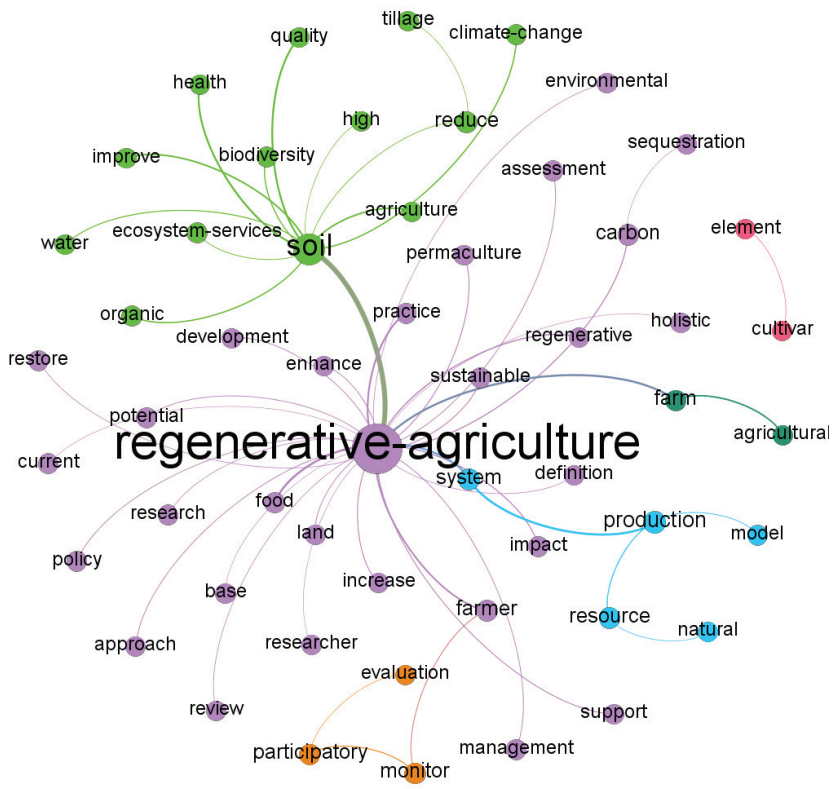

FIGURE 3
Co-occurrence of terms from the text of the title, abstract and keywords of 29 articles including "regenerative agriculture" in the article title. The network was based on a minimum of 5 co-occurrences between two terms, size of bubbles and text is proportional to term's grade (number of connections), and thickness of connections to the number of co-occurrence.

proposes a classification of different types of regenerative agriculture using the 10 elements that define agroecology (FAO, 2019; Barrios et al., 2020).

Agroecology and the different types of regenerative agriculture

There are clearly different types of regenerative agriculture. Based on our previous analysis and empirical evidence from our own observation, we propose to distinguish at least three broad types of RA. A first type that could be termed "philosophy" RA, as it represents the type adopted by individuals or networks based on philosophical principles such as healing the Earth and the human, farming in harmony with nature, etc., exhibiting close ties and often overlaps with holistic, people-centred approaches such as biodynamic farming, food forests, syntropy farming or permaculture (Box 1). While this type of RA does not involve political activism as does agroecology, it does involve social dimensions like human and social values. A second type comprises the regenerative farming approaches that are decidedly oriented to the restoration of soils and landscapes in smallholder agriculture contexts, in marginal or degraded environments, as part of broader rural development efforts that may also include interventions around health, value chains, nutrition, energy or sanitation. As this tends to be the approach of large international NGOs and development aid agencies, their approach to regenerative agriculture tends to be—well-intentioned but—top-down, massively deploying regenerative practices in communities and regions through projects that comprise typically thousands of households, in less than two- to three-years, to fulfil the expectations of international donors (Box 2). Finally, a "corporate" type of regenerative agriculture comprises the approaches followed by large enterprises, from local to multinational (farming operations, banks, chemical input companies, food processors, etc.), that place emphasis on agronomic practices such as conservation tillage (Box 3). Companies often present regenerative agriculture as part of their corporate sustainability programs.

The three types of regenerative agriculture identified above share in variable degrees the 10 elements that define agroecology (Table 1). The philosophy-type of regenerative agriculture

BOX 1 | AlVelAl: an example from South eastern Spain where agroecology and regenerative agriculture meet.

In recent years, community-based farming associations worldwide have started to promote RA to restore degraded landscapes using holistic approaches including social and economic objectives that can be easily associated with Agroecology. In these cases, the line that separates Agroecology and RA becomes blurred, and RA emerges as an approach to foster agroecological transitions, which embraces political activism to variable extents. This is the case of the AlVelAl agroecology association (www.alvelal.es) created in 2015 by local farmers with the support of the Commonland foundation (www.commonland.com), regional governments, local businesses, and research institutions. AlVelAl promotes RA in the high steppe plateau of southeast Spain to restore the natural, social, and financial capital of the region, and return inspiration to its people.

The high steppe plateau is one of Europe's regions most affected by desertification due to a combination of harsh environmental conditions and unsustainable land use practices (Martínez-Valderrama et al., 2016). The economy of the region relies largely on the primary sector and related markets. Its depressed economy is illustrated by a c. 30% rate of unemployment amongst its active population, and by the outmigration of young people contributing to the ageing and depopulation of the region. The landscape forms a mosaic integrating vast extensions of rainfed agriculture (mostly woody crops and cereals), esparto scrublands, and dry open Mediterranean forests (Figure 1). The region constitutes the world's largest area for the production of organic rainfed almonds.

The mechanization of farming activities and the use of agrochemicals promoted by the green revolution and endorsed by governmental institutions through subsidies to farmers until late 1990s, resulted in the abandonment of soil and water conservation structures (Bellin et al., 2009), the replacement of cereals for woody perennial crops (Cruz Pardo et al., 2010), the almost total disappearance of sheep farming (Toro-Mujica et al., 2015), and the intensification of tillage activities (Clar et al., 2018), resulting in a considerable increase in soil erosion rates (García-Ruiz, 2010). Socially, the region experienced a discontinuation of the traditional peasant lifestyle, and the loss of autonomy in their self-regulated resource-based system. The loss of farmers' autonomy is also reflected in their reduced economic profits and high dependence on subsidies to make farming economically viable (van Leeuwen et al., 2019).

AlVelAl seeks to enhance agroecosystem multi-functionality by promoting the diversification of organic almond orchards with the integration of sheep, fruit and other nut trees, aromatic herbs, bee keeping, and the reintroduction of traditional crops such as saffron. Regenerative practices at landscape and farm level promoted by AlVelAl include afforestation of degraded natural areas using native shrub and tree species, establishment and maintenance of landscape elements such as terraces and hedgerows, planting following contour curves, creation of water "harvesting" structures such as swales and ponds, minimization of tillage activities, implementation of cover crops and green manure, and preparation and application of bokashi compost and other organic amendments.

Beyond agronomic measures for the restoration of degraded landscapes and almond agroecosystems, AlVelAl enacts multiple mechanisms to revitalize the social and economic fabric of the region such as:

- **The co-creation and sharing of knowledge, practices and innovations tailored to the local context**, ranging from soil functioning, to regenerative farming, cultural heritage and education, promoting participatory and transdisciplinary processes, peasant to peasant knowledge exchange, and on-farm innovation experimentation, generating alliances with universities and research institutions.
- **The diversification of market options and self-managed value chains to enhance the independence of farmers with respect to the industry,** such as alternative distribution and commercialization channels, including the creation of an almond processing company and an online platform to market almonds, olive oil, wine and other organically certified products.
- **The creation of job opportunities to attract young people to the territory**, deploying financial incentives to support innovative business ideas that work on solutions to the climate and land degradation crisis based on soil and landscape restoration and related innovative business ideas, including tourism.
- **The valorization of the peasant life, food culture and traditions,** promoting agro-tourism activities and developing events such as the rural pride day, contributing to rebuilding a sense of place, cultural identity and spiritual nourishment of the inhabitants of the region.
- **Measuring and benchmarking success** by developing an integrative frame work to monitor RA impacts considering the ecological as well as the socio-economic and cultural dimensions of landscape restoration, and acknowledging the complexity of socio-ecosystems.

Photo: Farmer explaining green manure management and erosion control techniques at his farm during an open and free access activity organized by AlVelAl (photo retrieved from www.alvelal.es)

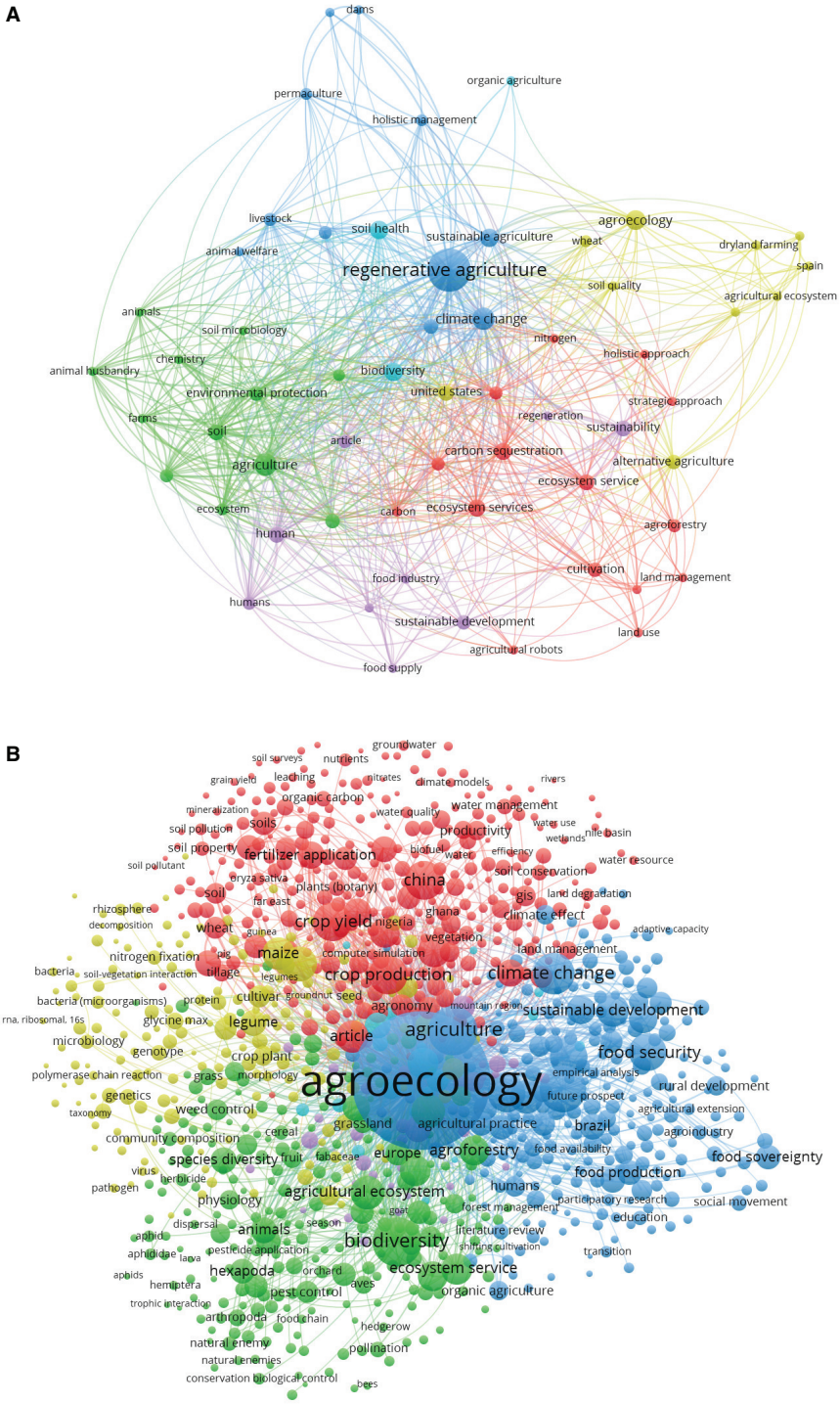

FIGURE 4
Co-occurrence network of keywords from **(A)** 101 articles related to regenerative agriculture and **(B)** 4,426 articles related to agroecology. The network was based on a minimum of 5 co-occurrences between two terms, size of bubbles and text is proportional to term's grade (number of connections), and thickness of connections to the number of co-occurrence.

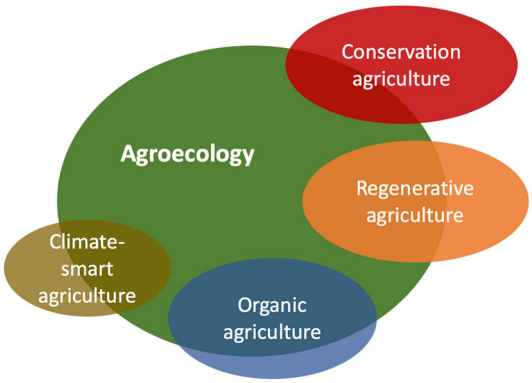

FIGURE 5
The relation between agroecology (science, practice and movement) and other approaches to sustainable agriculture, depicting their degree of overlap as intersecting sets. As a scientific discipline, agroecology provides the ecological knowledge that underpins sustainable practices under the other approaches.

shares in the basic ecological principles of agroecology, in terms of promoting diversity, efficiency (particularly radiation use efficiency), recycling, resilience (mostly ecological) and synergies or natural regulation and feedback. It also promotes human and social values, although with an emphasis on the individual (producer, consumer) and less often on the society as a whole. Co-creation of knowledge, food traditions, circular and solidarity economies and the responsible governance of natural resources are less often prioritised in this type of regenerative agriculture, although with notable exceptions (Box 1). Some networks that practice this type of regenerative agriculture even consider themselves to be part of the agroecology movement, which shows that the boundaries between these two approaches are often fuzzy.

The type of regenerative agriculture promoted by development organizations share in both the social and ecological principles of agroecology, on many of which there is a close match, such as efficiency in an agronomic sense, resilience (social and ecological), human and social values (gender equity, inclusiveness, youth opportunities), the co-creation and sharing of knowledge, and the respect for local cultures and food traditions. Since development agencies tend to promote single or a few technologies and practices through short-term projects, covering large numbers of households, their capacity to build on more complex principles that require a system redesign, such as diversity, recycling, circularity or synergies, is limited. Few are the cases so far in which solidarity and circular economy principles are effectively promoted through the work of international NGOs. Responsible governance is addressed mostly through what is known as landscape approaches (Campanhola et al., 2019), but the involvement of these agencies into local politics and policy-making in order to change contextual realities is generally limited.

Corporate regenerative agriculture, as promoted by large multinational companies, tends to focus on a few agronomic practices (typically no-tillage, mulching, cover crops) that, when implemented in isolation, have a limited impact at improving efficiencies, resilience (ecological) or synergies (Corbeels et al., 2020). Although corporations may proclaim that they favour principles such as diversity or circularity, the reality is that they continue working on large areas of single crop species grown year after year, usually relying heavily on external inputs (pesticides, fertilizers, GMOs), in production systems that may not include animals in their rotation. Use of cover crops is the most generalized practice, which are normally "terminated" through herbicide applications to create a mulch. So, while they may present an improvement as compared with business as usual in conventional large-scale monocultures, and represent a "gateway" opportunity that exposes large scale farmers to questions about sustainability, this type of RA shares the least number of principles with agroecology (Table 1) and exhibits the lowest potential to contribute to sustainable development of the socio-ecosystems as compared with the other two types.

Discussion

The limited yet rapidly emerging scientific literature on regenerative agriculture (RA) examined here emphasises its potential to restore soils, sequester carbon, increase biodiversity and use water more efficiently. The analysis of recently appeared articles with regenerative agriculture in their title resulted in four lexical clusters, centred around its definition and related concepts, around soils, production systems and marginally on social aspects (only a small cluster, based on the Luján Soto et al. articles related with the case described in Box 1). It is possible to affirm, in the light of the literature available, that the social and political dimensions, or the transitional and transformational processes necessary to arrive at future sustainable food production are virtually absent, so far, from most definitions of regenerative agriculture. Is it realistic to conceive transformative approaches to sustainable agriculture without politics? In other words, without questioning the structures and drivers that rendered agricultural systems as they are today: highly dependent on external inputs and financing, resource-degrading, deleterious to biodiversity and the environment, decontextualized, unfair, and unpopular. This is admittedly a rhetorical question, but one that is necessary to revisit once and again when proposing alternatives for positive transformational change of our current food systems.

We find it timely to highlight, however, that there are at least three broad types of RA, that differ in their degree to which they internalise social dimensions. They tend to share in the principles of agroecology that can be operationalised at farm level (cf. Figure 1), more readily than those that operate at

BOX 2 | Regenerative agriculture as a tool for sustainable development in Africa.

A growing number of development and aid organizations active in the African continent are taking up regenerative agriculture as part of their portfolio, as a tool to restore degraded land and mitigate/adapt to climate change. A concept that is closely associated with regenerative farming in the African context, especially when working with smallholder communities, is that of circular economy. Recycling and circular economies are also two of the 10 principles of agroecology (cf. Figure 1). There are also several examples of regenerative agriculture through agroforestry that resulted in specialty coffee or cocoa value chains (most of them can be found in European supermarkets nowadays). However, these products are not always necessarily labelled as "regenerative agriculture." In Africa, so far, most examples of projects that use the term "regenerative agriculture" come from southern Africa. Yet projects on soil restoration through conservation tillage, agroecology or agroforestry have yielded positive outcomes also in other parts of the continent. Most of these examples, however, are not from the academia but from practice, which means that they are not always properly documented in the scientific literature and hence hard to come by.

Deployment of Regenerative Agriculture and Circular Economy in Kenya

Let us take the example of Kenya, a low middle-income country ($3089 per capita national income; 66 years of life expectancy; human development index 147th out of 189), where several organizations are actively taking up regenerative and circular approaches to agriculture, although not always using such terms in their communication strategy. For example:

- The Land Accelerator has supported past projects in Kenya. In 2019 and 2018, they supported entrepreneurs who restored degraded forests and farmlands. They help young entrepreneurs and women in the field of land restorative business practices.
- TROCAIRE Kenya, a faith-based organization (FBO) associated with the Irish Catholic Church with regional offices in several African countries, their approach to food security and resource restoration uses agroecological principles, and emphasizes in the restoration of degraded lands through community efforts.
- Hand in Hand East Africa supports rural women to become empowered entrepreneurs, with a strong focus—but not exclusively—on agriculture and value chains; regenerative agriculture and circular economy are their approach to sustainable and climate-proof food production.
- Act 4 Change is working with the objective of training in practical agroecology, bio-intensive kitchen gardens, agroforestry and training for transformation methods. Their primary activities are outcome based—capacity building and increased food security; improvement in crop health. The major beneficiaries of their projects are FBOs, community-based (CBOs), and non-governmental organizations (NGOs).
- Zero Waste Kenya's Eco Designs project promotes sustainable, natural living as a way to personal growth, health and well-being, promotes livelihoods based on ecological values like permaculture, recycling natural building ultimately propelling self-sufficiency and empowerment of youth, women in communities.

Other organizations working on closely related approaches such as permaculture, agroecology, restoration and sustainable agriculture include GreenPot Enterprises, Africa Wood Grow, ReSCOPE, OTEPIC, Sustainable Village Resources (SVR), moofAfrica, Society for Alternate Learning and Transformation, Maasai Center for Regenerative Pastoralism, Badlisha, Laikipia Permaculture Centre, Justdiggit, KOFAR Kenya Ltd., Lentera Africa and Umoji Sofi, Circle Economy, GRID-Arendal and Shifting Paradigms.

Kenya is also a member of the African Circular Economy Network (ACEN) and various projects are implemented in Kenya. Other initiatives in Kenya in the agricultural or related sector *via* ACEN are:

- Humanure—Bio-waste, specifically human waste, to compost products;
- Safi Organics—decentralized transformation of rice char to organics;
- Ecodudu and InsectiPro—Black soldier fly farming for animal feed and crickets for human consumption;
- Sanergy—Converts toilet waste to fertilizer and animal feed using black soldier fly.

Photo: Collective design by a rural community in Busia, western Kenya, as part fo the "Regenerative Agriculture and Circular Economy" initiative led by the non-governmental organization Hand in Hand East Africa (https://handinhand-ea.org). Photo: J. Muli.

The experience in Africa and other regions indicate that successful approaches to support the transition to more sustainable agricultural production require not only technical innovation but also organizational and institutional innovation (Tittonell, 2014). Rolling out regenerative farming among smallholder farmer requires equipping development organizations with the strategy, capacities, and tools to embed this approach in their development models and in their policy messages.

BOX 3 | A multinational grain corporation taking up regenerative agriculture?

"We will advance regenerative agriculture on 1 million acres by 2030"

According to Lal (2020) the "question is not whether RA works or not, but how to make it work under site-specific conditions, including biophysical, social, economic, and the human dimensions." The goal of RA is to produce more from less: "less land area, less input of chemicals, less use of water, less emission of greenhouse gases, less risk of soil degradation, and less use of energy-based inputs."

However, a simple web search of "regenerative agriculture" will lead the reader to links, featuring among the top search records, to websites of multinational agri-food corporations such as General Mills, Syngenta, Cargill, Nestle, and others. The effects of the Green Revolution in the aftermath of the 1960s are widely documented and many of these companies are at the forefront of it. Could the advent of Regenerative Agriculture (RA) concepts, principles and practices lead to a Doubly Green Revolution? One that leads to increased ecological farming sustainably and that takes care of the communities. Why not?

General Mills, Inc. (GMI) for example, uses an outcome-based definition, as opposed to one based on practices, as follows: "Regenerative agriculture is a holistic, principles-based approach to farming and ranching that seeks to strengthen ecosystems and community resilience. RA improves the following outcomes: (1) Soil health, (2) Biodiversity, (3) Water, and (4) Farmer Economic Resilience." Reasonably, the company bases their approach to RA on critical issues, recognizing that:

- We are degrading soils at unsustainable rates / 30% of world soils are degraded
- Sustainability is no longer enough. We need to regenerate soils
- Top-soil = Black Gold / disappearing, 90% of our soils could be compromised
- Biodiversity loss is hurting agriculture / organisms perform functions that are essential to produce food, less pollinators = less fruits
- Agriculture remains a major threat to water / demand vs supply, water quality demand
- Farmers are under mounting economic pressure
- The climate impact of agriculture continues to increase

How can agriculture address those challenges? GMI proposes a science-based target of reducing greenhouse gases (GHG) emissions by 30% across the entire value chain (from farm to fork to landfill: upstream and downstream) over the next 10 years, and aims at having net zero emissions by 2050. This plan is named the "1.5°C Climate Ambition." To achieve this, RA is presented as a "Set of principles that can be applied by any farmer, anywhere" (https://www.youtube.com/watch?v=sm64gyd4BO4), as follows:

1. **Understand context**, since no two farms or farmers are the same. The key to success is to understand the context of a given field (its soils and climate, its constraints and opportunities), and then to develop a plan to integrate the other principles based on that context.
2. **Minimize disturbance** like tillage (ploughs, or discs) or over-use of pesticides and insecticides can disrupt the agroecosystem functions. Thus, the first important step is to let the soil and ecosystem recover.
3. **Maximize crop diversity** to "feed the soil a diverse diet, which improves soil health."
4. **Keep the soil covered** to reduce erosive impact from sun, rain, and wind
5. **Keep a living root year-round** or, as long as possible throughout the year, increasing atmospheric Carbon storage and turnover to "feed the soil"
6. **Integrate livestock into croplands** and manage them in dense herds with frequent moves. This will improve nutrient cycling and soil health

Basically, GMI proposes that, when integrated in a "system" by a farmer, these principles enable both organic and conventional farmers to regenerate their soil and the rest of the farm ecosystem. Root biomass is thus used to improve water cycling into the deeper layers of the soil. Across the Northern Plains, the Southern Plains, and the Great Lakes regions of the United States (illustration below), GMI intends to "work from the ground-up, starting by regenerating 1 million acres." In order to accelerate what GMI names a "farmer-led movement," the company has made a commitment to advance RA on 1 million acres by 2030. GMI has pioneered in partnering with farmers (also known as "Regen Ag Pilots") to create an enabling environment for RA adoption through (a) Education, (b) 1-on-1 Coaching, (c) Build Community, and (d) Monitor Soil-Wildlife-Profit. Additionally, they are exploring (e) Ecosystem Service Markets in the Southern Plains.

In the case of large corporations, whether "green-washing" occurs or not is difficult to judge from terms such as "alternative food systems (regenerative, agroecology, organic, sustainable)" as used in the companies' websites. The large and multiple definitions of RA allow for space to market business activities. A key agronomic practice that is recurrently mentioned are cover crops and the "power of roots." This inherits from Conservation Agriculture and is largely based on agroecological farmer innovations. To some extent, the need for corporations to freshen their public image is understandable. However, agroecology advocates often argue that the mis-placed use of "regenerative" ideas, or co-optation, without real system transformation is "green-washing." In short, plain practice without politics, can be considered merely a business-as-usual scheme that omits social justice considerations but plays the card of caring for the environment. Grasping the subtleties in the use of "regenerative agriculture" from a diversity of food system actors seems an appropriate trade-off to embrace.

Sources:
https://www.generalmills.com/en/Responsibility/Sustainability/Regenerative-agriculture
https://www.wri.org/insights/regenerative-agriculture-good-soil-health-limited-potential-mitigate-climate-change
https://www.jswconline.org/content/jswc/early/2020/07/31/jswc.2020.0620A.full.pdf

—

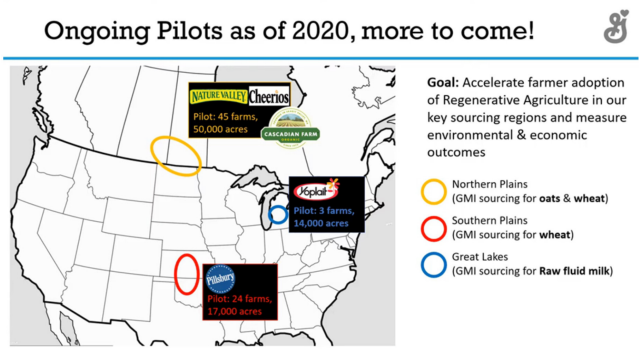

Illustration:
General Mills RA pilot regions. Source: https://www.youtube.com/watch?v=VpctrjFN9U0

TABLE 1 A comparison between agroecology and three different types of regenerative agriculture (RA), using the 10 elements that define agroecology (FAO, 2019).

Agroecology	Philosophy RA	Development RA	Corporate RA
Science, practice, movement: social and ecological principles, landscape approaches, bottom-up, different sources of knowledge	RA as adopted by individuals or networks, based on philosophical principles, close to permaculture or biodynamic approaches	RA as promoted by development organizations, social and ecological principles, landscape approaches, often top-down, close to organic and low input farming	RA as proclaimed by enterprises, based on practical agronomic principles and corporate sustainability approaches, close to conservation agriculture
Diversity			
Efficiency*			
Recycling			
Resilience			
Synergy			
Human and social values			
Co-creation and sharing of knowledge			
Food culture and traditions			
Circular and solidarity economy			
Responsible governance			

*Efficient use of solar radiation, water, nutrients, energy and labor, based on primary productivity.
Green = close match; Yellow = partial match; Red = no match (for the color blind, respectively: 75% light dotted; 100% even; 25% light dotted).

community level (cf. Figure 1). The categorization we propose is admittedly arbitrary, it aims to highlight three broadly different approaches to RA, but the boundaries between them are fuzzy. A continuous gradient or a "palette" would probably be better to describe the diversity of RA approaches that exist in reality. organizations that promote and practice what would fall in the category of "philosophy" RA (Table 1; Box 1) do emphasise the social dimension of agricultural sustainability, and may also engage in politics. Those who approach regenerative agriculture from the realm of permaculture, in particular, advocate for "just and reciprocal relationships" or "growing together" through their principles (e.g., McLennon et al., 2021). Development-oriented organizations promoting regenerative agriculture, particularly in the poorest rural regions of the world (cf. Box 2), are undoubtedly highly motivated by the creation of social justice. However, their approach which tends to be top-down due to practical reasons (e.g., aiming at reaching thousands of households in a short period of time), sometimes fails at empowering communities to design and implement their own regenerative practices. They may be less effective at co-creating knowledge, or at increasing farm-level diversity, two key elements of agroecology (Figure 1; Table 1). Fundamentally, and in spite of their very good will, they might unintentionally contribute to re-creating paternalist relationships and community's dependence on external aid, if they are not careful. Landscape approaches to community resource governance and self-learning mechanisms to support context-specific regenerative design are promising ways to counterbalance this.

Yet, when it comes to describing the practical approaches under the category "development RA", it is necessary to open a new parenthesis to clarify one particular point about practices. The brief review of the history and definitions of RA presented earlier shows that this is a concept that emerged in North America, and expanded later on to Europe, Latin America, Australia, parts of Asia and most recently Africa. However, there is a wide diversity of approaches to soil, water, biodiversity and ecosystem restoration practiced in Africa which, although not labelled as RA, share most of its principles and practices. For example, Corral-Nuñez et al. (2014) documented doubling of soil carbon stocks through community exclosures, afforestation and rotational grazing on very degraded soils in a marginal environment in Tigray, Ethiopia; Lahmar et al. (2012) and Félix et al. (2018) show great potential to restore degraded land in the Sahel by managing native shrubs biomass together with conservation farming techniques; Nezomba et al. (2015) describe a case of soil regeneration in Zimbabwe using native annual legume species that they term "indifallows." All of these are examples of RA options that use locally available knowledge and resources (reducing costs and external input dependence) and improve agricultural productivity, which ultimately leads to more profitable farming (lower costs and higher productivity). As explained in the example of Box 2, many of these examples come from practice rather than

research, and they are not always well documented in the scientific literature.

The third type of regenerative agriculture identified was qualified as "corporate" (Table 1; Box 3). The net effect of presenting RA as synonym of corporate sustainability by large agri-business and food companies, banks and financers, and even governments and traditional research organizations, may not necessarily be positive in terms of getting closer to achieving agricultural sustainability in all its true dimensions. It may actually backfire, when either the promised outcomes are not achieved, or when the resulting association between RA and green-washing campaigns negatively influences choices by farmers, consumers, nature or development organizations, and governments. In their definition of RA, companies tend to confound principles and practices (cf. Box 3), or processes and outcomes. And one may also wonder whether corporate regenerative approaches are truly devoid of any politics. Simplifying the definition of RA in the way they do allows, for example, to count every farmer that seeds cover crops in a part of the farm as a *practitioner* of regenerative agriculture—a way to arrive quickly at the millions of hectares of adoption being promised. To what extent is soil health improved, carbon sequestered, water captured and stored, or biodiversity restored in the claimed millions of hectares under corporate RA? Without evaluating proper process and outcome indicators, this becomes just another rhetoric around sustainability. Yet, this is not to say that the adoption of RA principles or practices by large-scale commercial farmers and agro-firms is completely fruitless. RA can in some case become a vector that conveys sustainability messages (soil, carbon, biodiversity, climate change) into the agricultural debate even amongst those who are most recalcitrant to change.

Processes first, outcomes will follow

Our quick overview of the top internet sources on regenerative agriculture illustrates that definitions vary across organizations and they may be based on principles, on practices, on processes, or on outcomes (cf. Section A diversity of RA definitions). Several definitions tend to implicitly assume that a certain practice or process will inevitably lead to a given outcome. For example, using no-tillage to sequester carbon in the soil. A weak point around this assumption is often in the lack of contextual evidence to support the link between processes and outcomes. In the case of no tillage, following this example, there is evidence that it can lead to carbon sequestration in certain contexts (i.e., soil types, climatic conditions, type of production systems, etc.) and not in others (Giller et al., 2009). Likewise, since soils tend to saturate in terms of the amount of carbon they can store, no-tillage may lead to carbon sequestration when soils are degraded, regenerating their fertility, but not once the soil is restored and carbon-saturated. If the promises of these practices regarding outcomes are not met, or if there is insufficient support to overcome technological, social, institutional, and economic challenges for implementation, dis-adoption of alternative farming practices may be common (Chinseu et al., 2019). This emphasises the need for collaborative design of farming objectives and practices to better suit local needs and contexts, and to recognize the societal benefits beyond individual economic benefits (de Groot et al., 2022). Adoption of regenerative farming practices can also benefit from the development of transdisciplinary research incorporating farmers' knowledge and building on farmer-to-farmer knowledge exchange (Luján Soto et al., 2021). When aiming at building sustainability, resilience and adaptive capacities, such co-innovation processes, with all the learning and social cohesion that is generated through them (Rossing et al., 2021), may be more important at fostering long-term sustainable transitions than the initially promised outcomes in term of soil, water, carbon and biodiversity.

Apolitical discourses fall short

It is often assumed that emphasising the social and political dimensions of farming is only relevant when working with smallholder farmers in the global South. This is a misconception. The social and political dimensions of farming influence practices (processes) and outcomes also in the most advanced economies. Let us take The Netherlands as an example, the second world exporter of agricultural products (measured in Euros), with an intensive and professional agriculture that produces the highest yields per unit of land or animal in almost every sector. The financial outlook for many Dutch farmers is however grim, especially among arable farmers, while the social appreciation of farmers has declined. This resulted in a constant reduction in the number of active famers in The Netherlands from 97,390 in 2000 to 52,700 in 2020, and an average age of the farmer that is reaching 60 years old, as they struggle to find a successor. On the other hand, companies that lend money, sell inputs and technologies, insure properties, provide services, etc. to the agricultural sector are striving, at the expense of heavily indebted, subsidized, and psychologically stressed farmers (Furey et al., 2016; Daghagh Yazd et al., 2019; Rudolphi et al., 2020; Tittonell et al., 2020; Wookjae et al., 2020; Hagen et al., 2021; Vermunt et al., 2022). Can the agronomic principles of regenerative agriculture versing on soils, carbon, water and biodiversity (cf. Section Regenerative agriculture concepts and terminology), by themselves, improve the financial and psychological situation the farmers are in, reduce the decline in the number of active farmers, and bring us to a more equitable agricultural and food production system? Partly yes, or not at all, depending on several circumstances. But what is certain is that both, in the North and in the South, one of the

keys to sustainable agriculture or sustainable soils is the mere sustainability and resilience of the rural livelihoods themselves. Enhancing the sustainability and resilience of rural households requires much more than regenerative agricultural practices.

Conveying a definition of resilience that is also devoid of politics, most advocates of RA portrait it as an approach "beyond sustainable" that, by restoring soils, is able to build resilience and improve the adaptability of agriculture in the face of global change. Apolitical resilient thinking is widely accepted as a normative good, which actually responds to the hegemonic neoliberal subjectivity (Calo, 2020). Resilience and adaptation in agriculture are often presented as a matter of the individual responsibility of a "decision-maker," without discussing aspects of the broader context such as land tenure regimes or power relations (Cretney, 2014). This vision ignores (i) that resilience is often achieved through organizational innovations and/or collective efforts (e.g., Murray and Zautra, 2012; Petersen-Rockney et al., 2021), and (ii) that there are farmers who are not able to adopt, adapt or innovate due to resource insecurity or barriers to accessing them, legitimizing unjust situations (e.g., Easdale et al., 2016; Horst and Marion, 2018). Such narrow conceptualizations of technical resilience are increasingly normative in political debates (Smith and Stirling, 2007; Joseph, 2013; Kepkiewicz and Dale, 2018; Calo, 2020; Cretney, 2014). Thus, two excluding proposals that advocate for sustainability and resilience are those that oppose the urgency for changes in land governance vs. changes in land management. The first one comes from agrarian scholars and peasant movements around the world, such as the *Via Campesina* (Giraldo and Rosset, 2017). The second one rests on the logic that a single or a few management units are able to operate positive large-scale changes based on regenerative, conservation or climate-smart agriculture, as often promoted by nature conservation organizations, governments or development agencies (Borras and Franco, 2018). This contributes to explaining why agribusiness interests show an early articulation with RA (cf. Box 3), which offers to preserve or restore ecological functions without challenging power relations (Wozniacka, 2019).

Through our practice, we observe that RA initiatives that embrace socio-political dimensions and rely on social movements can be transformative (cf. Luján Soto et al., 2020). In such sense, we are convinced that RA may learn a few useful lessons from current worldwide efforts to scaling up agroecology (cf. Mier y Terán Giménez Cacho et al., 2018). Thanks to the development of public policies promoted and co-constructed by social movements, agroecology has been scaled up to variable degrees in different countries (i.e., Brazil, Cuba, India, Mexico, France, Argentina). The degree of success at scaling up agroecology in these countries depends, among other drivers, on the development of specific public policies. Such policies involved on the one hand, the reformulation and roll-back of policies supporting the reproduction of industrial agriculture, and on the other, the support of pathways for the transformation of agri-food systems based upon agroecological principles. The need for combinations of complementary policies is crucial to support agroecological transitions, to tackle the various issues at stake, including strengthening social movements and addressing the farming, education, and market sectors (e.g., Caporal and Petersen, 2011; Henderson and Casey, 2015; Coolsaet, 2016; Bhattacharya, 2017). One may assume that this should also be the case when attempting to scale up RA. Yet with one additional obstacle: having to build legitimacy.

Legitimacy is the acceptance of knowledge, norms, customs, or technologies as being credible and authoritative, and their support and/or adoption by stakeholders (Montenegro de Wit and Iles, 2016). The convenient apolitical discourse of RA resulted in the advent of new research groups, organizations, development and policy actors joining the "beyond sustainable" wave. Groups, individuals or even governments that have historically questioned or even opposed agroecology, organic, and other alternative approaches, are now carving themselves an opportunistic niche in the realm of RA, speaking of "climate-proof" or "future-proof" agricultural solutions. How legitimate would such new actors be in order to set a credible agenda for a new agriculture that produces healthy food, restores soils and biodiversity, while cooling the planet and adapting to global change remains to be seen.

Conclusions: Agroecology without politics?

The answer to the rhetorical question posed in the title of this opinion piece should be definitely, no! In the first place, because there are several types of regenerative agriculture, some of which embrace social and political dimensions to some extent. And one may argue that there are politics involved, directly or indirectly, in the three forms of RA proposed here. Secondly, because agroecology is much more comprehensive than regenerative agriculture, and not just in terms of socio-political aspects. In spite of the diversity of RA definitions available, most practitioners/adopters would agree that soil health and soil restoration are at their core. Agroecology, on the other hand, encompasses social dimensions but also additional biophysical dimensions of agriculture than the proponents of regenerative agriculture claim to include, such as crop breeding, energetics, crop protection, ecology and genetics, circularity, multitrophic polycultures, etc. Although we cannot claim that we have exhausted all possible definitions and approaches to RA available, our review of the widely accessible web-based and scientific information on RA has been extensive, and the lexical analysis performed on it quite assertive.

Regenerative agriculture needs a comprehensive definition that (i) rests on scientific evidence, (ii) allows informing new theories of change (i.e., clearly differentiating between

principles, practices, processes and outcomes), and (iii) avoids co-optation of the approach for green-washing purposes. A comprehensive definition, one that allows articulating RA with sustainability and resilience, needs to incorporate the social and political dimensions of agri-food transitions and transformations. The three types of RA that co-exist, namely "philosophy RA," "Development RA" and "Corporate RA," share in different degrees the ecological and social principles of agroecology, more easily at farm than at community level. By creating tighter links with the science and movement of agroecology, and fundamentally, by engaging in much needed political debates to foster agri-food transitions and transformations, regenerative agriculture will be able to build broader legitimacy among the relevant stakeholders.

Author contributions

PT developed the idea, wrote the article, and reviewed case studies. VE conducted the lexical analysis and contributed to writing. GF, YK, RL, and JD developed one of the case studies and contributed to writing. LL conducted literature review and contributed to writing. All authors contributed to the article and approved the submitted version.

Conflict of interest

The 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.

Publisher's note

Supplementary material

The Supplementary Material for this article can be found online at: https://www.frontiersin.org/articles/10.3389/fsufs.2022.844261/full#supplementary-material

References

Barrios, E., Gemmill-Herren, B., Bicksler, A., Siliprandi, E., Brathwaite, R., Moller, S., et al. (2020). The 10 Elements of Agroecology: enabling transitions towards sustainable agriculture and food systems through visual narratives. *Ecosyst. People* 16, 230–247. doi: 10.1080/26395916.2020.1808705

Bellin, N., van Wesemael, B., Meerkerk, A., Vanacker, V., and Barbera, G. G. (2009). Abandonment of soil and water conservation structures in Mediterranean ecosystems: A case study from south east Spain. *CATENA* 76, 114–121. doi: 10.1016/j.catena.2008.10.002

Bhattacharya, N. (2017). Food sovereignty and agro-ecology in Karnataka: Interplay of discourses, identities, and practices. *Develop. Pract.* 27, 544–554. doi: 10.1080/09614524.2017.1305328

Borras, S. M., and Franco, J. C. (2018). The challenge of locating land-based climate change mitigation and adaptation politics within a social justice perspective: towards an idea of agrarian climate justice. Third *World Q.* 39, 1308–1325. doi: 10.1080/01436597.2018.1460592

Calo, A. (2020). "Who has the power to adapt?" frameworks for resilient agriculture must contend with the power dynamics of land tenure. *Front. Sustain. Food Syst.* 4, 259. doi: 10.3389/fsufs.2020.555270

Campanhola, C., Stamoulis, K., and Pandey, S. (2019). Chapter 48—sustainable agriculture and food systems: the way forward (London: Academic Press), 551–555.

Caporal, F. R., and Petersen, P. (2011). Agroecologia e políticas públicas na América Latina: O caso do Brasil. *Agroecologia* 6, 63—74. Available online at: https://revistas.um.es/agroecologia/article/view/160681

Chinseu, E., Dougill, A., and Stringer, L. (2019). Why do smallholder farmers dis-adopt conservation agriculture? insights from *Malawi. L. Degrad. Dev.* 30, 533–543. doi: 10.1002/ldr.3190

Clar, E., Martín-Retortillo, M., and Pinilla, V. (2018). The Spanish path of agrarian change, 1950–2005: from authoritarian to export-oriented productivism. *J. Agrar. Chang.* 18, 324–347. doi: 10.1111/joac.12220

Coolsaet, B. (2016). Towards an agroecology of knowledges: Recognition, cognitive justice and farmers' autonomy in France. *J. Rural Stud.* 47, 165–171. doi: 10.1016/j.jrurstud.2016.07.012

Corbeels, M., Naudin, K., Whitbread, A. M., Kühne, R., and Letourmy, P. (2020). Limits of conservation agriculture to overcome low crop yields in sub-Saharan Africa. *Nat. Food* 1, 447–454. doi: 10.1038/s43016-020-0114-x

Corral-Nuñez, G., Opazo-Salazar, D., GebreSamuel, G., Tittonell, P., Gebretsadik, A., Gebremeskel, Y., et al. (2014). Soil organic matter in Northern Ethiopia, current level and predicted trend: a study case of two villages in Tigray. *Soil Use Manag.* 30, 487–495. doi: 10.1111/sum.12157

Cretney, R. (2014). Resilience for whom? emerging critical geographies of socio-ecological resilience. *Geogr. Compass* 8, 627–640. doi: 10.1111/gec3.12154

Cruz Pardo, J., Yanes Punga, M., Sanchez Rojas, C. P., and Simon Mata, M. (2010). *Ambientes semiáridos del sureste andaluz: el Altiplano esteparío*. Sevilla: Consejería de Medio Ambiente. p. 721.

Daghagh Yazd, S., Wheeler, S. A., and Zuo, A. (2019). Key risk factors affecting farmers' mental health: a systematic review. *Int. J. Environ. Res. Public Health* 16, 4849. doi: 10.3390/ijerph16234849

Day, C., and Cramer, S. (2021). Transforming to a regenerative U.S. agriculture: the role of policy, process, and education. *Sustain. Sci.* 21, 7. doi: 10.1007/s11625-021-01041-7

de Groot, R., Moolenaar, S., de Vente, J., De Leijster, V., Ramos, M. E., Robles, A. B., et al. (2022). Framework for integrated Ecosystem Services assessment of the costs and benefits of large scale landscape restoration illustrated with a case study in Mediterranean Spain. *Ecosyst. Serv.* 53, 101383. doi: 10.1016/j.ecoser.2021.101383

Easdale, M. H., Aguiar, M. R., and Paz, R. (2016). A social-ecological network analysis of Argentinean Andes transhumant pastoralism. *Reg. Environ. Change.* 16, 2243–2252. doi: 10.1007/s10113-015-0917-8

Elevitch, C. R., Mazaroli, N. D., and Ragone, D. (2018). Agroforestry standards for regenerative agriculture. *Sustain.* 10, 3337. doi: 10.3390/su10093337

FAO (2019). *TAPE Tool for Agroecology Performance Evaluation 2019—Process of development and guidelines for application*. Test version. Rome

Félix, G. F., Clermont-Dauphin, C., Hien, E. (2018). Ramial wood amendments (Piliostigma reticulatum) mitigate degradation of tropical soils but do not replenish nutrient exports. *Land Degrad Dev.* 29, 2694–2706. doi: 10.1002/ldr.3033

Francis, C. A., Harwood, R. R., and Parr, J. F. (1986). The potential for regenerative agriculture in the developing world. *Am. J. Alternat. Agri.* 1, 65–74. Available online at: http://www.jstor.org/stable/44506928

Furey, E. M., O'Hora, D., McNamara, J., Kinsella, S., and Noone, C. (2016). The roles of financial threat, social support, work stress, and mental distress in dairy farmers' expectations of injury. *Front. Public Health* 4, 126. doi: 10.3389/fpubh.2016.00126

Gabel, M. (1979). *Ho-Ping: Food for Everyone, 1st Edn*. Garden City, NY: Anchor Books.

García-Ruiz, J. M. (2010). The effects of land uses on soil erosion in Spain: a review. *CATENA* 81, 1–11. doi: 10.1016/j.catena.2010.01.001

Giller, K. E., Hijbeek, R., Andersson, J. A., and Sumberg, J. (2021). Regenerative agriculture: an agronomic perspective. *Outlook Agric.* 50, 13–25. doi: 10.1177/0030727021998063

Giller, K. E., Witter, E., Corbeels, M., and Tittonell, P. (2009). Conservation agriculture and smallholder farming in Africa: The heretics' view. *Field Crops Res.* 114, 23–34. doi: 10.1016/j.fcr.2009.06.017

Giraldo, O. F., and Rosset, P. M. (2017). Agroecology as a territory in dispute: Between institutionality and social movements. *J. Peasant Stud.* 17, 356. doi: 10.1080/03066150.2017.1353496

Gliessman, S., and Tittonell, P. (2015). Agroecology for food security and nutrition. *Agroecol. Sustain. Food Syst.* 39, 131–133. doi: 10.1080/21683565.2014.972001

Green, T., van den Brink, R., Talbert, J., and Sarode, S. (2021). Regenerative agriculture: what every CCA needs to know. *Crop. Soils* 54, 37–43. doi: 10.1002/crso.20121

Hagen, B. N. M., Sawatzky, A., Harper, S. L., O'Sullivan, T. L., and Jones-Bitton, A. (2021). What impacts perceived stress among canadian farmers? a mixed-methods analysis. *Int. J. Environ. Res. Public Health* 18, 7366. doi: 10.3390/ijerph18147366

Hanson, H. C. (1939). Ecology in agriculture. *Ecology* 20, 111–117. doi: 10.2307/1930733

Henderson, C., and Casey, J. (2015). Scaling up agroecology through market systems: using technology justice in agriculture to leave no one behind. Rugby: Practical Action Publishing.

Horst, M., and Marion, A. (2018). Racial, ethnic and gender inequities in farmland ownership and farming in the U.S. *Agric. Hum. Values* 36, 1–16. doi: 10.1007/s10460-018-9883-3

Ikerd, J. (2021). The economic pamphleteer: realities of regenerative agriculture. *J. Agric. Food Syst. Community Dev*. 10, 7–10. doi: 10.5304/jafscd.2021.102.001

Joseph, J. (2013). Resilience as embedded neoliberalism: a governmentality approach. *Resilience* 1, 38–52. doi: 10.1080/21693293.2013.765741

Kepkiewicz, L., and Dale, B. (2018). Keeping 'our' land: property, agriculture and tensions between Indigenous and settler visions of food sovereignty in Canada. *J. Peasant Stud.* 6150, 1–20. doi: 10.1080/03066150.2018.1439929

LaCanne, C. E., and Lundgren, J. G. (2018). Regenerative agriculture: Merging farming and natural resource conservation profitably. *PeerJ.* 2018, e4428. doi: 10.7717/peerj.4428

Lahmar, R., Bationo, B. A., Lamso, N. D., Guéro, Y., and Tittonell, P. (2012). Tailoring conservation agriculture technologies to West Africa semi-arid zones: building on traditional local practices for soil restoration. *Field Crops Res.* 132, 158–167. doi: 10.1016/j.fcr.2011.09.013

Lal, R. (2020). Regenerative agriculture for food and climate. *J. Soil Water Conserv*. 75, 123A-124A. doi: 10.2489/jswc.2020.0620A

Luján Soto, R., Cuéllar Padilla, M., and de Vente, J. (2020). Participatory selection of soil quality indicators for monitoring the impacts of regenerative agriculture on ecosystem services. *Ecosyst. Serv*. 45, 101157. doi: 10.1016/j.ecoser.2020.101157

Luján Soto, R., Cuéllar Padilla, M., Rivera Méndez, M., Pinto-Correia, T., Boix-Fayos, C., and de Vente, J. (2021). Participatory monitoring and evaluation to enable social learning, adoption, and out-scaling of regenerative agriculture. *Ecol. Soc.* 26, 429. doi: 10.5751/ES-12796-260429

Lunn-Rockliffe, S., Davies, M. I., Willman, A., Moore, H., McGlade, J. M., and Bent, D. (2020). *Farmer Led Regenerative Agriculture for Africa*. London: Institute for Global Prosperity.

Malik, P., and Verma, M. (2014). Organic agricultural crop nutrient. *Res. J. Chem. Sci*. 4, 94–98.

Martínez-Valderrama, J., Ibáñez, J., Del Barrio, G., Sanjuán, M. E., Alcalá, F. J., Martínez-Vicente, S., et al. (2016). Present and future of desertification in Spain: Implementation of a surveillance system to prevent land degradation. *Sci. Total Environ.* 563, 169–178. doi: 10.1016/j.scitotenv.2016.04.065

McLennon, E., Dari, B., Jha, G., Sihi, D., and Kankarla, V. (2021). Regenerative agriculture and integrative permaculture for sustainable and technology driven global food production and security. *Agron. J.* 21, 814. doi: 10.1002/agj2.20814

Mier y Terán Giménez Cacho, M., Giraldo, O. F., Aldasoro, M., Morales, H., Ferguson, B. G., Rosset, P., et al. (2018). Bringing agroecology to scale: key drivers and emblematic cases. *Agroecol. Sustain. Food Syst*. 42, 637–665. doi: 10.1080/21683565.2018.1443313

Montenegro de Wit, M., and Iles, A. (2016). Toward thick legitimacy: Creating a web of legitimacy for agroecology. *Elementa.* 4, 000115. doi: 10.12952/journal.elementa.000115

Mottet, A., Bicksler, A., Lucantoni, D., De Rosa, F., Scherf, B., Scopel, E., et al. (2021). Assessing transitions to sustainable agricultural and food systems: a tool for agroecology performance evaluation (TAPE). *Front. Sustain. Food Syst.* 4, 252. doi: 10.3389/fsufs.2020.579154

Murray, K., and Zautra, A. (2012). "Community resilience: fostering recovery, sustainability, and growth," in *The Social Ecology of Resilience: A Handbook of Theory and Practice*, ed M. Ungar (New York, NY: Springer), 337–345.

Newton, P., Civita, N., Frankel-Goldwater, L., Bartel, K., and Johns, C. (2020). What is regenerative agriculture? a review of scholar and practitioner definitions based on processes and outcomes. *Front. Sustain. Food Syst*. 4, 194. doi: 10.3389/fsufs.2020.577723

Nezomba, H., Mtambanengwe, F., Tittonell, P., and Mapfumo, P. (2015). Point of no return? Rehabilitating degraded soils for increased crop productivity on smallholder farms in eastern Zimbabwe. *Geoderma* 239, 143–155. doi: 10.1016/j.geoderma.2014.10.006

Petersen-Rockney, M., Baur, P., Guzman, A., Bender, S. F., Calo, A., Castillo, F., et al. (2021). Narrow and brittle or broad and nimble? Comparing adaptive capacity in simplifying and diversifying farming systems. *Front. Sustain. Food Syst*. 5, 564900. doi: 10.3389/fsufs.2021.564900

Rhodes, C. J. (2017). The imperative for regenerative agriculture. *Sci. Prog*. 100, 80–129. doi: 10.3184/003685017X14876775256165

Rodale, R. (1983). Breaking new ground-the search for a sustainable agriculture. *Futurist.* 1, 15–20.

Rosset, P. M., and Altieri, M. A. (2017). Agroecology: sciencie and politics. London: Practical Action Publishing.

Rossing, W. A. H., Albicette, M. M., Aguerre, V., Leoni, C., Ruggia, A., and Dogliotti, S. (2021). Crafting actionable knowledge on ecological intensification: Lessons from co-innovation approaches in Uruguay and Europe. *Agricult. Syst.* 190, 103103. doi: 10.1016/j.agsy.2021.103103

Rudolphi, J. M., Berg, R. L., and Parsaik, A. (2020). Depression, anxiety and stress among young farmers and ranchers: a pilot study. *Community Ment Health J.* 56, 126–134. doi: 10.1007/s10597-019-00480-y

Sayer, J., Terry, S., Jaboury, G., Jean-Laurent, P., Douglas, S., Erik Meijaard, M., et al. (2013). Ten principles for a landscape approach to reconciling agriculture, conservation, and other competing land uses. *PNAS* 110, 8349–8356. doi: 10.1073/pnas.1210595110

Schreefel, L., Schulte, R. P. O., de Boer, I. J. M., Schrijver, A. P., and van Zanten, H. H. E. (2020). Regenerative agriculture—the soil is the base. *Glob. Food Sec*. 26, 100404. doi: 10.1016/j.gfs.2020.100404

Smith, A., and Stirling, A. (2007). Moving outside or inside? objectification and reflexivity in the governance of socio-technical systems. *J. Environ. Policy Plann.* 9, 351–373, doi: 10.1080/15239080701622873

Struik, P. C., and Kuyper, T. W. (2017). Sustainable intensification in agriculture: the richer shade of green. a review. *Agron. Sustain. Dev.* 37, 39. doi: 10.1007/s13593-017-0445-7

Tittonell, P., Piñeiro, G., Garibaldi, L. A., Dogliotti, S., Olff, H. and Jobbagy, E. G. (2020). Agroecology in large scale farming: a research agenda. *Front. Sustain. Food Syst*. 20, 605. doi: 10.3389/fsufs.2020.584605

Tittonell, T. (2014). Ecological intensification—sustainable by nature. *Curr. Opin. Environ. Sustain.* 8, 53–61 doi: 10.1016/j.cosust.2014.08.006

Toro-Mujica, P. M., Aguilar, C., Vera, R., Barba, C., Rivas, J., and García-Martínez, A. (2015). Changes in the pastoral sheep systems of semi-arid Mediterranean areas: association with common agricultural policy reform and implications for sustainability. *Spanish J. Agric. Res*. 13, e0102. doi: 10.5424/sjar/2015132-6984

van Leeuwen, C. C. E., Cammeraat, E. L. H., de Vente, J., and Boix-Fayos, C. (2019). The evolution of soil conservation policies targeting land abandonment and soil erosion in Spain: a review. *Land use policy* 83, 174–186. doi: 10.1016/j.landusepol.2019.01.018

Vermunt, D. A., Wojtynia, N., Hekkert, M. P., Van Dijk, J., Verburg, R., Verweij, P. A., et al. (2022). Five mechanisms blocking the transition towards ?nature-inclusive? agriculture: A systemic analysis of Dutch dairy farming. *Agricult. Syst.* 195, 103280. doi: 10.1016/j.agsy.2021.103280

White, C. (2020). Why Regenerative Agriculture? *Am. J. Econ. Sociol.* 79, 799–812. doi: 10.1111/ajes.12334

Wookjae, H., Jae Min, L., and Narang, P. (2020). Financial-related psychological factors affect life satisfaction of farmers. *J. Rural Stud.* 80, 185–194. doi: 10.1016/j.jrurstud.2020.08.053

Wozniacka, G. (2019). *Big Food is Betting on Regenerative Agriculture to Thwart Climate Change. Civ. Eats.* Available online at: https://civileats.com/2019/10/29/big-food-is-betting-on-regenerative-agriculture-to-thwart-climate-change/ (accessed April 24, 2020).