crops

MDPI

Review

Variations and Commonalities of Farming Systems Based on Ecological Principles

Anil Shrestha * and David Horwitz

Department of Plant Science, California State University, Fresno, CA 93740, USA
* Correspondence: ashrestha@mail.fresnostate.edu

Abstract: In the last few decades, various types of farming systems based on ecological principles have been proposed and developed. There is often interest in knowing about the differences between these systems, but such information must be obtained from several sources describing each of these systems. Therefore, this paper is an effort to consolidate the information on these systems in a concise manner without making comparative ratings between them. We found three components contained in the overarching theme of these systems: the reduction in external inputs, environmental protection, and sustainability. However, several variations exist between them, each with its own focus and guiding principles. Also, these farming systems contain their own specific terms to identify themselves and contain their own set of philosophies based on their founder. In this review, we provided a short description of some of the major ecologically based farming systems such as "agroecology", "regenerative agriculture", "holistic management", "carbon farming", "organic farming", "permaculture", "biodynamic farming", "conservation agriculture", and "regenerative organic farming". We summarized these farming systems as "variants of farming systems based on ecological principles" and outlined the similarities and differences between them. We also discussed how the themes of these systems relate to the United Nations' thirteen principles of agroecology. Although these systems share several similarities, their philosophy is rooted in their founders and the communities that choose to adopt these philosophies. Last, we discussed some of the challenges in implementing these ecological agriculture systems.

Keywords: agroecology; biodynamic farming; carbon farming; conservation agriculture; holistic management; organic farming; permaculture; regenerative agriculture; regenerative organic farming; UN principles of agroecology

check for updates

Citation: Shrestha, A.; Horwitz, D. Variations and Commonalities of Farming Systems Based on Ecological Principles. *Crops* **2024**, *4*, 288–307. https://doi.org/10.3390/crops4030021

Academic Editor: Kenneth J. Moore

Received: 27 May 2024
Revised: 24 June 2024
Accepted: 4 July 2024
Published: 8 July 2024

Copyright: © 2024 by the authors. Licensee MDPI, Basel, Switzerland. This article is an open access article distributed under the terms and conditions of the Creative Commons Attribution (CC BY) license (https://creativecommons.org/licenses/by/4.0/).

1. Introduction

Human survival during the 1960s and the 1970s faced a major challenge in many parts of the world due to food crises caused by population increases, famines, declines in crop productivity, and political, demographic, and economic turbulences. In some cases, these resulted from the aftereffects of the two world wars [1–5]. The Green Revolution was a major contribution that helped to combat these issues, but it resulted in monocultures dependent on substantial external inputs [6] and a loss of indigenous crops [7]. However, the Green Revolution was necessary to meet the food demands of the rapidly increasing population, shortages caused by widespread famines, decreasing crop productivity, and declining human health [8–10]. There are numerous examples of the contributions of the Green Revolution, including increasing crop productivity, improving human health, and combating other global adversities threatening human survival, and this resulted in further economic development. For example, crop production increased by almost three times in only 50 years when compared to the amount of food produced before the Green Revolution. Further, cultivated land only increased by 30% [6]. This increase in world food production was swifter than the increase in the world population resulting in a decline in the food consumption rates in many parts of the world [1]. Furthermore, the Green Revolution

resulted in a 2.5 to 5.3% reduction in infant mortality, particularly in poor households, and countries known as food insecure in the 1960s became emerging economies [11].

In the last few decades, the importance of agricultural systems based on sound ecological principles has been a major emphasis [12–14]. In other words, the impetus is on the incorporation of ecological principles into farming practices [15]. One example is to reduce external inputs and to protect the environment from agricultural pollutants created by these inputs [16,17]. The emphasis results from the beliefs and findings that post-Green Revolution farming and industrial agriculture systems that developed out of the Green Revolution rely heavily on external inputs. These include hybrid varieties of the major cereal crops that only respond now to high amounts of synthetic chemical fertilizers and increased irrigation, and these trends decreased soil health. This, in turn, resulted in these crops' susceptibility to varied agricultural pests and hence drove the need for synthetic pesticides. This, in turn, decreased biodiversity by developing monocultures, displaced traditional climate-resilient crops and varieties, increased environmental pollution, and caused social inequalities [7,18–27].

These problems, believed to derive from industrial, post-Green Revolution agriculture, led to the call, definition, and implementation of sustainable agricultural systems. The definition of sustainable agriculture in the US is an "*integrated system of plant and animal production practices having a site-specific application that will over the long-term: satisfy human food and fiber needs; enhance environmental quality and the natural resource base upon which the agriculture economy depends; make the most efficient use of nonrenewable resources and on-farm resources and integrate, where appropriate, natural biological cycles and controls; sustain the economic viability of farm operations; and enhance the quality of life for farmers and society as a whole*" [28]. It is important to acknowledge that each country may have a different definition of sustainable agriculture; thus, it is beyond the scope of this paper to consolidate the differences between the definitions.

From the definition above, sustainable agriculture includes components beyond basic agronomy, crop production, and the boundary of the farm. Therefore, farms came to be considered human-managed ecosystems that included a complexity of biological, physical, chemical, social, and economic interactions that aimed to produce crops in a sustainable manner. In other words, such a system was termed an "agroecosystem", meaning the farms and the entities it served and received services from were an ecological system [29–31]. However, an understanding of the importance of the role of ecology in agriculture can be seen as early as 1928, when a few institutions started offering curricula in "crop ecology" [32]. The term "crop ecology" was later broadened to reflect the complexity of agroecosystems. However, several variations of farming systems based on these ecological principles exist. These farming systems define their own specific terms to identify themselves and follow philosophies set by the founders of these farming systems. A common theme that we found is that these farming systems present themselves as an alternative to external chemical input-reliant farming systems, which they often seem to term "conventional agriculture". There is often interest, and in many cases confusion, about the differences between these systems among growers, students, and academicians. Similarly, consumers are also confused by the food labeling process of these systems. However, there seem to be very few publications that provide an overview of all of these systems in one article. Therefore, this paper is an effort to consolidate the information on these systems in a concise manner without making comparative analytical ratings between them or with "conventional agriculture". The objective of this article is to provide a general overview of each of these farming systems and describe how they conform to the United Nations Food and Agriculture Organization principles of agroecology that are being promoted for global food security. In the section below, we discuss some of these farming systems, which we consider "*variants of farming systems based on ecological principles*".

2. Variants of Farming Systems Based on Ecological Principles

2.1. Agroecology

There are historical examples of ecological practices utilized in agriculture as early as the 16th century [33]. However, the credit for the initial use of the word "agroecology" in 1928 goes to a Russian agronomist Basil Bensin [34]. Thereafter, various definitions of agroecology arose, and Pimbert et al. [33] considered them to be "four distinct phases of the definitions of agroecology". The definitions of Altieri [35] and Gliessman [36] helped agroecology gain recognition as a system and principle for designing sustainable agriculture in the first phase. The definition by Thomas and Kevan [37], the "*application of ecological concepts and practices for the design and management of sustainable agroecosystems*", was considered as the second phase. Francis et al.'s [38] definition of agroecology, taking an observation of food systems in their entirety, considered the "*ecology of food systems*", as the third phase. Lastly, most of the newer definitions include aspects of social movements, food sovereignty, and people's rights along with ecology [39–41]; this is considered the fourth phase. Gliessman [42], in an article solely focused on the definitions of agroecology, summarizes that "*Agroecology is the integration of research, education, action and change that brings sustainability to all parts of the food system: ecological, economic, and social*".

As mentioned above, many variations exist that define agroecology to apply exclusively to their own movement. However, the United Nations Food and Agriculture Organization (FAO), after multi-stakeholder workshops, identified ten key elements of agroecology and launched them as a framework in April 2018. The elements include diversity; the creation and sharing of knowledge; synergies; efficiency; recycling; resilience; human and social values; culture and food traditions; responsible governance; and a circular and solidarity economy [43]. Furthermore, Wezel et al. [21] developed a list of thirteen principles of agroecology that include recycling, input reduction, soil health, animal health, biodiversity, synergy, economic diversification, the co-creation of knowledge, social values and diets, fairness, connectivity, land and natural resource governance, and participation [21]. Some scholars suggest that agroecology is more of a social movement adopted by rural people [44,45], and publications can be found providing examples of the role of people in bringing about transformation through agroecology [46].

Therefore, we summarize "agroecology" as a variant of farming systems based on ecological principles with its own subset of clearly defined principles and elements on local and international scales. Agroecology is an overarching theme of a farming system or many farm systems, which integrates research, education, and the food system in its entirety and sometimes acts as a social movement in several parts of the world.

2.2. Regenerative Agriculture

"Regenerative agriculture" is a term coined by George Washington Carver and was defined by Robert Rodale in the 1980s as "one that, at increasing levels of productivity, increases our land and soil biological production base. It has a high level of built-in economic and biological stability. It has minimal to no impact on the environment beyond the farm or field boundaries. It produces foodstuffs free from biocides. It provides for the productive contribution of increasingly large numbers of people during a transition to minimal reliance on non-renewable resources" [47].

"Regenerative agriculture", a variant of ecological agriculture, contains the widest array of definitions, depending on who describes it: academicians, scientists, growers, non-governmental and governmental agencies, or industry. In the case of academicians and scientists, there is a lack of a rigid scientific definition, and it is mainly based on the views of the individuals defining it [48]. After surveying 28 peer-reviewed articles to consolidate a more singular understanding of the term, another team of reviewers gave regenerative agriculture the following definition: "*an approach to farming that uses soil conservation as the entry point to regenerate and contribute to multiple provisioning, regulating and supporting ecosystem services, with the objective that this will enhance not only the environmental, but also the social and economic dimensions of sustainable food production*" [48]. Similarly, after reviewing the

definition of regenerative agriculture in 229 journal articles and 25 practitioner websites, they concluded that process- and outcome-based definitions for the term are utilized most. They suggested that the process-based definitions came from advocators or users of the definition who had open minds about the possible outcomes of the processes, whereas those who chose outcome-based definitions implicitly used more open-minded definitions about the processes leading to those outcomes [49].

The Iowa Soybean Association [50], among the various grower association definitions, broadly defines "regenerative agriculture" as "*a systems approach of thinking about soil health and the practices that encourage carbon response and maintaining a balance between sol health and water quality*". The non-governmental agency Regeneration International [51] defines "regenerative agriculture" as "*farming and grazing practices that, among other benefits, reverse climate change by rebuilding soil organic matter and restoring degraded soil biodiversity—resulting in both carbon drawdown and improving the water cycle*". The United States Department of Agriculture (USDA) does not seem to hold a particular definition for "regenerative agriculture". The California Department of Food and Agriculture (CDFA) brought together a workgroup to define "regenerative agriculture", which defined it as "*regenerative agriculture includes approaches that help mitigate climate change, improve soil health, restore biodiversity, enhance ecosystems, and contribute to human health*" [52]. Similarly, the FAO also does not have a set definition and describes it as "*an inclusive agroecosystems approach for conserving land and soil, biodiversity, and improving ecosystem services within farming systems with the focus on regeneration of living soil, improved micro hydrology, and biodiversity conservation at all levels while enhancing inputs use efficiency and ecosystem system services*" [53].

A wide array of agriculture input industry definitions of "regenerative agriculture" also exist. For example, the Syngenta Group [54] defines it as "*an outcome-based food production system that nurtures and restores soil health, protects the climate and water resources and biodiversity, and enhances farms' productivity and profitability*". Furthermore, they state that "*It comprises a range of techniques, supported by innovative technologies, which can combat the challenges cause by climate change by restoring the health of soil and protecting the land's ecosystem*".

In summary, "regenerative agriculture" can be viewed as a variant of ecological agriculture that bases itself on several principles and the elements of agroecology described above. Based on these several definitions, the emphasis of "regenerative agriculture" seems to be more about improving soil health by maximizing the addition of soil organic matter, using reduced inputs, and incorporating traditional farming methods and some more recent strategies. Examples include fixing atmospheric carbon dioxide (CO_2) through crops into the soil by methods such as polycultures, integrating crops and livestock into simple management systems, and practicing no-till farming [55]. Emphasis is also on growing vegetation across a farm's entire landscape to reduce erosion, increase the soil's carbon (C) holding capacity, and promote biodiversity. The latter is achieved in these systems in part by attracting pollinators and pest predators [21]. Furthermore, like agroecology, some definitions of "regenerative agriculture" include socio-political justice concerns. Some examples include fair wages for farm workers, worker's protection, food equity and accessibility, and supporting the localized production systems native to a region. Although sustainability seems like the general theme of "regenerative agriculture", not all definitions seem to embrace all parameters of sustainability [55].

2.3. Holistic Management

"Holistic management", a term coined in the 1960s by Alan Savory, promotes decision making as an approach to managing resources, primarily grazing systems in animal agriculture [56,57]. Some perceive the philosophy to be more of a "permaculture" applied to rangeland management [58]. Holistic management seeks to "regenerate" ecologically degraded soil and plant life and other biologically challenged environmental processes occurring within whole landscapes. The emphasis is on seeing landscapes as operating as singular whole systems. At the same time, it seeks to regenerate soil health and on-farm biodiversity and the financial wellbeing and quality of life of people living amongst the

landscapes. The approach focuses on preventing desertification by maintaining a steady state of balance between the natural resources, which, in ecological terms, is the "dynamic equilibrium". "Holistic management" derives its practices from four major principles: "Brittleness Scale", "Nature Functions in Wholes", "Predatory Connection", and "Plant and Soil Recovery Time" [59].

The "Brittleness Scale" principle operates through assessing water availability over the course of a year and learns the extent of plant decomposition during the grassland's growing and dormancy periods through the perspective of ten categorical levels. "Nature Functions in Wholes" states that in wild ecosystems, relationships and interactions between plants and animals drive natural processes. The "Predator-Prey Connection" centers around replicating the relationships between herding animals and pack-hunting predators, believing that this relationship lends itself to grassland soil health. It advocates land managers to implement rotational grazing by moving animals in herds and allowing them to eat all vegetation and not just grass. The disturbance and aeration of the compacted soils by hooves of the herd, Allan Savory suggests, function as a beneficial, low-intensity tillage. The process also aids in grass decomposition, the consumption of wild plants, and the deposition of fertilizer with urine, and it is said to stimulate new plant growth regrowth. "Plant and Soil Recovery Time" seeks to balance the damages caused by grazing and trampling by brief durations of grazing followed by lengthier periods of non-grazing so that the soil and vegetation can completely recover [59].

Thus, we consider that "holistic management" functions as a variant of ecological agriculture and is also based on several principles and elements of "agroecology". The emphasis of "holistic management" is on improving soil health by rotational grazing of animals and the social and economic wellbeing of people living in the landscape.

2.4. Carbon Farming

It is unclear who coined the term "carbon farming", but to broadly define it, carbon farms act as a system that adopts restorative land use and site-specific best management practices to help create a positive soil ecosystem C budget. This process sequesters atmospheric CO_2 in the soil and biomass, thus increasing soil and collectively across farmlands and terrestrial C stock [60]. It also emphasizes the importance of farming with perennial crops to foster more C sequestration over a longer growth period. Thus, "C farming" seeks to reduce the negative impacts of climate change [61]. Practitioners of "C farming" receive economic benefits in the form of different types of payments [60,62]. The European Commission [62] defines "carbon farming" as "*A green business model that rewards land managers for taking up improved land management practices, resulting in the increase of carbon sequestration in living biomass, dead organic matter and soils by enhancing carbon capture and/or reducing the release of carbon to the atmosphere, in respect of ecological principles favorable to biodiversity and the natural capital overall*".

Perennial cropping systems that do not need much tillage are favored over annual cropping systems that need substantial soil disturbance [63]. As such, there are some articles on crop choices for "C farming". Advocates propose that crops for "C farming" should have larger and deeper functional root biomass to increase the belowground C allocation, enhance interactions with soil microbes to increase rhizosphere sink strength, and aid in enhanced nutrient acquisition and water use efficiency; this results in increased source strength for enhanced photosynthesis and biomass accumulation [64]. Proponents suggest that perennial cropping systems store more CO_2 over longer durations because they are photosynthetically active for several years. Because of this, more C is turned over to the soil microbiome through root exudates. Also, agroforestry systems utilizing tree crops together with understory crops, cover crops, and livestock have the capacity to store large amounts of CO_2 [65]. Furthermore, the amount of C sequestration is affected by regional climactic and soil variances [63]. Soils with more biological activity aboveground and belowground may foster C sequestration more than soils with less biological activity. Tropical agroecosystems accumulate more C in their aboveground tissues than in the soil

below, while temperate climate agroecosystems, particularly perennial ones, retain most of their C reserves in the soil where roots are located [66].

"Carbon farming", like "regenerative agriculture", carries multiple definitions, promoted by various academicians and researchers, governmental and non-governmental agencies, industries, and producer groups. For example, academic and research sectors established a Carbon Farming Alliance for Research and Management (C-FARM) [67]. Governmental agencies, such as the USDA and EU, promoted "C farming" by providing economic incentives [62,68]. Non-governmental agencies, such as Green America, view "C farming" as a practice that offsets emissions, restores degraded soils, enhances crop production, and reduces pollution by minimizing erosion and nutrient runoff, purifying surface and groundwater and increasing microbial activity and soil biodiversity [69]. Industries such as Bayer Group have established "The Bayer Carbon Program" that pays growers who enroll in the program for adopting cover crops and reducing tillage practices. The program also terms it as the "adoption of qualifying regenerative practices" [70]. Producer groups, such as the National Corn Growers Association, USA, promote "C farming" as a means of reducing greenhouse gas emissions and view C markets as a potential to obtain a new source of income for participants [71].

Hence, "carbon farming" is also a variation of ecological agriculture that is also based on several principles and elements of "agroecology". The emphasis of "C farming" is on increasing C sequestration, improving soil health, and reducing agricultural pollution to mitigate climate change. However, the practice seems to rely on economic incentives in the form of C markets. A review of 40 global case studies found that result-based, action-based, and hybrid payments provided the three main incentive mechanisms for "C farming" contracts and concluded that the success of "C farming" relied on understanding the details of the contract design [72]. A study also reported the complexity of the burdensome and unpredictable nature of receiving offset credits as a concern among farmers and that many farmers already practice "C farming" without terming their practice "C farming" [73]. Therefore, it may be of interest to see what the future offers for "C farming" without economic incentives. Regardless, the term bases itself on some of the agroecological principles.

2.5. Organic Farming

The term "organic farming" originated in 1940 by Lord Northbourne in the book "Look to the Land" [74]. However, others cite Sir Albert Howard, F. H. King, and Rudolf Steiner as the first people to develop the concepts of organic agriculture in the early 1900s. Howard first learned from the traditional farming practices in India and advocated for their adoption in the West. In the US, J.I. Rodale and his son Robert receive formal recognition for initially promoting organic agriculture in the 1940s [75].

Organic agriculture's relationship to "agroecology" stems from its emphasis on soil humus building. In fact, Kuepper [76], citing Northbourne [77], stated that the term "humus farming" was replaced by "organic farming" in 1940. Humus has been defined as follows: "*Chemically, humus consists of certain constituents of the original plant material resistant to further decomposition; of substances undergoing decomposition; of complexes resulting from decomposition, either by processes of hydrolysis or by oxidation and reduction; and of various compounds synthesized by microorganisms*" [78]. The positive role of humus in agriculture mostly involves increases in soil fertility [79–81]. "Organic farming" is considered to accumulate more humus in the soil than conventional farming because of diverse crop rotations [81], and humus increases soil C, nutrient availability, and soil water holding capacity over time [82].

There are various definitions of "organic agriculture". At the international level, the FAO/Whole Health Organization Codex Alimentarius commission defines it as follows. "*Organic agriculture is a holistic production management system which promotes and enhances agroecosystem health, including biodiversity, biological cycles, and soil biological activity. It emphasizes the use of management practices in preference to the use of off-farm inputs, taking into account that regional conditions require locally adapted systems. This is accomplished by using, where possible,*

agronomic, biological, and mechanical methods, as opposed to using synthetic materials, to fulfill any specific function within the system" [83]. In the US, the USDA defines it as "*the application of a set of cultural, biological, and mechanical practices that support the cycling of on-farm resources, promote ecological balance, and conserve biodiversity. These include maintaining or enhancing soil and water quality; conserving wetlands, woodlands, and wildlife; and avoiding use of synthetic fertilizers, sewage sludge, irradiation, and genetic engineering*" [84].

The four principles of "organic agriculture" developed by the International Federation of Organic Agriculture Movements (IFOAMs) deal with the challenges of globalization, including health, ecology, fairness, and care [85]. In the US, organic agriculture functions more as a regulatory system that is kept by pre-established rules, regulations, and guidelines that undergo strict monitoring. These guidelines hold the key requirements, including the requirement to use only non-synthetic pesticides and fertilizers, implement cultural, biological, and mechanical techniques to preserve water and fertility on site, avoid damaging the surrounding ecosystems, and maintain farmland biodiversity. Organic systems do not allow the production of genetically modified organisms (GMOs) because proponents believe they are not natural [84].

Therefore, "organic agriculture" as a variation of ecological agriculture bases itself on several principles and elements of "agroecology" described above. The emphasis of "organic agriculture" is on building humus for soil health, while strictly regulating organic farming systems by not allowing the usage of any synthetic products and GMOs. The system has a monitoring mechanism by regulators in several countries in the world where registered growers must abide by the regulations to get their products certified as organic. In some countries, they consider the term as entailing farming systems that are based on the use of natural inputs instead of synthetic pesticides and fertilizers and ones that practice crop rotations and implement plant and animal biodiversity with an emphasis on other holistic farming practices.

2.6. Permaculture

"Permaculture" as a term derives itself from the words "permanent culture" and "permanent agriculture", as coined by David Holmgren and Bill Mollison of Australia in 1978. Their inspiration for "permaculture" came from observing wild ecosystems in the Tasmanian rain forests [86]. "Permaculture" can be defined as "*Consciously designed landscapes which mimic the patterns and relationships found in nature, while yielding an abundance of food, fibre and energy for provision of local needs*" [87].

As a design principle-based agroecosystem, "permaculture" tries to promote sustainability of the farmland by designing synergies between abiotic and biotic components such that the system can yield abundant food, medicine, shelter, and other multifunctional benefits to humans. The system bases itself on some foundational guidelines and principles and a strong emphasis on recycling with the belief that there is no such thing as waste in nature. The concept proposes techniques for organic gardening, recycling, developing renewable energy, consensually deciding matters important to groups, buildings that use sustainable, natural models and parts, and the pursuit of social justice as tools of "permaculture" [86].

The basis of "Permaculture" rests on twelve principles: observe and interact, catch and store energy, obtain a yield, apply self-regulation and accept feedback, use and value renewable resources and services, produce no waste, design from patterns to details, integrate rather than segregate, use small and slow solutions, use and value diversity, use edges and value the marginal, and creatively use and respond to change [87]. In essence, by design, it is a self-sustaining system that aims to reduce its needs for irrigation, build humus-rich soil, grow plants or crops most adapted to the local climate, densely plant perennial or annual crops, plant beneficial cover crops, and plant native and ornamental plants together to maximize interception and the utilization of sunlight and reduce evaporation. It also utilizes mulches, rainwater harvesting, and recycling graywater [86]. Some researchers state that "permaculture" principles quite closely resemble agroecological approaches, but

"permaculture" is different in how it provides a guide to the design, implementation, and maintenance of the system [88].

In essence, "permaculture" is a farming system based on the philosophy of Holmgren and Mollison that, in essence, functions as a variation of ecological agriculture but with a clearly defined set of principles; stepwise, they provide unique guidelines to the design, implementation, and maintenance of the agroecosystem.

2.7. Biodynamic Farming

"Biodynamic farming" emerged as a philosophical method of holistic farming in 1924 and was developed by Rudolf Steiner. However, Kutschera [89] credits Ernst Haeckel of Germany for the origin of the word in 1866 and stated that "*its original meaning was perverted by the founders of the organic movement in agriculture*". Therefore, "biodynamic farming" receives credit for the onset of "organic agriculture" by some authors, [90] or an alternative form of "organic agriculture" [91]. Critics of "biodynamic farming" cite the philosophy as being based on "pseudo-scientific" and "esoteric" concepts [89,92,93], as many of its practices derive from beliefs in cosmic and terrestrial energies, which practitioners believe act to harmonize soil-building processes. These processes are believed to be achieved by making nine different preparations for stimulating and harmonizing these ethereal cosmological energies [94]. However, some authors believe "biodynamic" farmers to be open to scientific knowledge, yet they admit they combine it with experiential and spiritual knowledge [95]. Several practices of "biodynamic farming", except for the nine preparations and conducting operations according to the lunar and astrological calendar, are like "organic agriculture" [94]. "Biodynamic farming" considers soils as living systems that become restored by organic matter. The organic matter additions derive from adopting practices such as green manuring, crop rotation, and cover crops. They believe in bringing factors that maintain life by bringing it into balance and treating manure and compost in a biodynamic way [96] according to cosmic calendars [94]. In a review of 147 scientific papers, researchers concluded that "biodynamic agriculture" focuses on enhancing soil quality and biodiversity and human health using the OneHealth approach [92].

According to the Biodynamic Demeter Alliance [97], a national organization focused on biodynamic agriculture and food systems in the USA, "biodynamic farming" encapsulates a conceptual philosophy founded on the principle that a farm functions holistically as an unbroken single organism. The principles try to mimic natural ecological biogeochemical cycles mixed with spiritual and mystical practices. They consider the whole farm to be an organism comprised of co-dependent and inter-relating elements. These could include surrounding grasslands, woodlands, forests, agroforests, fields, animals, the soils on and surrounding the farms, compost, people, and as characterized by the founder, "*the spirit of the place*". This farming system tries to foster biodiversity on the farm by emulating wild ecosystems and integrates annual and perennial vegetables, herbs, flowers, berries, tree fruits, nuts, grains, pasture, forage, native plants, and pollinator-attracting hedgerows as ways to foster and intensify plant diversity. This, practitioners believe, aids the health of the farm organism. There is also an emphasis on diversifying domestic animals, with the belief that each type of animal brings a unique relationship to the land and endows the vitality of the land with different manure qualities.

Like "organic agriculture", "biodynamic farming" undergoes systematic certification under "The Demeter Biodynamic (R brand) Standard", which is led worldwide by the organization Demeter International. Biodynamic certification in the USA uses the USDA organic certification standards [98] as a base standard in addition to the requirements of Demeter International, Demeter USA The Demeter Biodynamic Farm Standard views the entire farm as an ecosystem, basing its certification process on this view rather than basing certification on or around a specific crop's management practices [97].

Therefore, "biodynamic farming" as a form of ecological agriculture is based on the philosophy of Haeckl and Steiner [89], whoy practice farming based on beliefs rooted in cosmic and astrological calendars. They practice a holistic system of farming with a

continuum of soil to human health while maintaining its own standards defined by a certification system of its own. Several cropping techniques mirror "organic agriculture", such as the emphasis on soil-building efforts and promoting biodiversity by several cropping practices. These share holistic management practices in common with the other variants of ecological agriculture.

2.8. Conservation Agriculture

The term "conservation agriculture" was coined by the FAO in the 1990s with ideas of minimizing soil disturbance that originated during the US Dust Bowl in the 1930s. The FAO defines "conservation agriculture" as "*a farming system that promotes minimum soil disturbance (i.e., no tillage), maintenance of a permanent soil cover, and diversification of plant species. It enhances biodiversity and natural biological processes above and below the ground surface, which contributes to increased water and nutrient use efficiency and to improved and sustained crop production*" [99]. The system is based on three principles that include minimum mechanical soil disturbance, permanent soil organic cover, and species diversification. These principles are achieved through the adoption of "conservation tillage", which includes practices such as zero-tillage or no-tillage farming, leaving crop residues on the soil surface, including cover crops, and practicing crop rotations [100]. These are again among the overlapping principles of the variations of ecological agriculture described earlier, with common benefits, such as increases in soil microbial biomass C and N [101] and reductions in CO_2 emissions [102], as well as disadvantages, such as increases in the weed populations [103] and increased labor in implementation [104]. There are examples of the adoption of such systems in various parts of the world. For example, "conservation agriculture" in eastern and southern Africa was thought to be a climate-smart system that could develop resilient smallholder farming systems [105]. It was concluded that the adoption of "conservation agriculture" could help in sustainably producing more food from less land, promoting more efficient use of natural resources, and minimizing the impact on the environment [100].

Again, "conservation agriculture" is also a form of ecological agriculture where the emphasis is on minimizing soil disturbance and maintaining the organic cover of the soil surface, much like that of undisturbed natural ecosystems. It is a system formally defined by the FAO but does not contain the regulatory and branding practices used in some of the other ecological agriculture systems discussed earlier. Also, the mention of social welfare in this system is not mentioned explicitly but it is implied in terms of minimizing negative impacts on the environment.

2.9. Regenerative Organic Farming

"Regenerative organic" agriculture fuses the principles of "organic agriculture", such as the disallowing of synthetic inputs and GMOs, promoting the building of the soil humus levels, and supplying crop nutrition through the soil. In addition, it integrates "regenerative agriculture" and "C farming" in its goals of fighting anthropogenic climate change and saving global topsoil. "Regenerative organic" uses the "Regenerative Organic Certified®" certification system and claims that it "represents the highest standard for organic agriculture in the world, with stringent requirements for soil health, animal welfare, and social fairness". Regenerative Organic Certified® is based on the USDA Certified Organic standard [98] but adds three major pillars of "regenerative organic" to its certification program. The three pillars include soil health and land management, animal welfare, and farmer and worker fairness [106].

In essence, "regenerative farming" is a form of ecological agriculture based on the philosophy of "organic agriculture". As a formally certified system, it undergoes regulation and it incorporates its own certification process, which uses the USDA's organic certificate program as a basis for that certification. It also contains three additional requirements relating to environmental protection and human welfare and wellbeing.

A summary of all the farming systems discussed above is presented in Table 1.

Table 1. Summary of the variants of the ecological farming systems.

Farming System	Founder/s and Year	Salient Features/Theme
Agroecology	Basil Bensin, 1928	Based on ecological principles with its own subset of clearly defined principles and elements on local and international scales. Integrates research, education, and the food system in its entirety and is more of a social movement in several parts of the world.
Regenerative agriculture	George Washington Carver, 1940/Robert Rodale, 1980	Based on ecological principles but with more emphasis on improving overall soil health with ecological methods. Similar to agroecology; some definitions of "regenerative agriculture" include socio-political justice concerns and support for local production systems.
Holistic management	Alan Savory, 1960s	Based on ecological principles but puts more emphasis on improving soil health by the rotational grazing of animals and the social and economic wellbeing of people living in the landscape.
Carbon farming	Unknown	Based on ecological principles but with more emphasis on increasing carbon sequestration, improving soil health, and reducing agricultural pollution to mitigate climate change. The system relies on economic incentives in the form of carbon markets.
Organic farming	Lord Northbourne, 1940	Based on ecological principles but with more emphasis on building humus for soil health; regulations do not allow the usage of any synthetic products and do not allow the use of GMOs. Registered growers must abide by the regulations to get their products certified as "organic". In some countries, it is a farming system based on the use of natural inputs instead of synthetic pesticides and fertilizers and one that practices crop rotations, biodiversity, and emphasis on other holistic farming practices.
Permaculture	David Holmgren and Bill Mollison, 1978	A farming system based on the philosophy of Holmgren and Mollison. A variation of ecological agriculture with a clearly defined set of stepwise principles that provide unique guidelines for the design, implementation, and maintenance of the agroecosystem.
Biodynamic farming	Rudolf Steiner, 1924	A form of ecological agriculture where the farming practices are based on beliefs rooted in cosmic and astrological calendars. A holistic system of farming with a continuum of soil to human health while maintaining its own standards defined by a certification system of its own. Several techniques are similar to "organic agriculture".
Conservation agriculture	FAO, 1990s	A form of ecological agriculture with emphasis on three major base principles. These three are minimum mechanical soil disturbance, permanent soil organic cover, and species diversification.
Regenerative organic farming	Robert Rodale, 1980	Based on the philosophy of "organic agriculture". Has a formal regulated process that uses the USDA's organic certification program but has three additional requirements relating to environmental protection and human welfare and wellbeing.

3. Overarching Themes of the Variations of Ecological Agriculture Programs and How They Meet the UN's 13 Principles of Agroecology

The overarching principles of all the variants that move ecological agriculture systems forward, as discussed above, include environmental aspects and economic and social aspects. The environmental impacts of all the systems acting as functional movements revolve around soil health. They seek to foster greater organic matter levels in the soil for continued arability of land. They all try to facilitate natural ecosystem functions to reduce inputs on the farm by planting cover crops or completely covering farmland with planned perennial and annual vegetation. They also promote the integration of livestock into cropping systems. Several of these systems seek to combat climate change by adopting certain farming systems that help in building healthy soils and store C as organic matter. Another overarching principle that they all include is biodiversification. They perform this by utilizing hedgerows, planting trees in annual cropping systems, planting polycultures and mixed cropping systems, using cover crop mixes for soil microbiome diversification, planting wildflowers between crops and around the fields to attract beneficial insects and pollinators, and practicing crop rotations and diversified agroforestry systems. Social equity, social justice, and fairness function as important components, at least ideally, as all of these systems are driven by social movements.

The first principle of the UN principles of agroecology, "recycling", occurs as a common theme in all the systems. The second principle, "input reduction", also occurs as a common theme in all the systems, except for "C farming", which does not mention this ideal as an outright principle but implies it from the other principles that it maintains. All the systems meet the UN's third principle of "soil health", with some of the systems being more specific about the practices than others. For example, "C farming" emphasizes planting deep-rooted, long-living perennial crops, and "permaculture" outlines a design scheme to maximize soil health. "Organic farming" promotes soil health by its "feed the plant by feeding the soil" principle. "Biodynamic agriculture" adds spiritual and ritual components to promote soil health. "Holistic management" seeks to improve soil health by intensive rotational grazing.

"Animal health" is the fourth UN principle for healthy agroecosystems. Again, some of the systems are more explicit about this than others. For example, "biodynamic agriculture" explicitly presents itself as a system that is a caretaker of animals. It refuses to clip animal horns off, allowing them to forage on open pastureland and letting smaller animals eat weeds and insects. "Holistic management" seeks to ensure animal wellbeing by enabling livestock mobility. "Regenerative agriculture" and "regenerative organic" both aim to promote animal health and welfare by letting livestock graze and forage freely across farmland. "Carbon farming" seeks to improve animal health through silvopasture systems [63]. "Permaculture" is not explicit about animal health but discusses ways to promote mammalian or avian domesticated animal health by biodiversifying their farm systems and growing insectary plants; in this way, they are beneficial for crop arthropods and larger vertebrates [86].

The fifth principle of the UN's agroecology vision, "biodiversity", can also be found as a central theme of all the system-driven movements but with slightly different motives. For example, "C farming" promotes "biodiversity" through multi-strata perennial cropping systems and agroforestry systems, as well as integrating livestock with fodder trees in silvopasture systems [107]. "Organic farming" relies on biodiversity to manage pests, facilitating hedgerows and flower plantings to attract beneficial pest predator insects [108]. "Holistic management" attempts to promote biodiversity by managing grazing systems [109]. "Regenerative agriculture" practices biodiversification of the belowground environment by providing constant vegetal cover of the farmland's topsoil by cover cropping, planting multi-cropping systems, and including trees in fields, as well as planting hedgerows and wildflowers and including livestock in cropping systems [55]. By practicing no-till farming, regenerative systems also preserve fungal and bacterial biodiversity underground [110]. "Regenerative organic" promotes the same practices as "organic" and

"regenerative". "Permaculture" promotes biodiversity through organized companion plantings to promote the health and vigor of food forest trees' soil biome while also including weeds as alternative food sources and soil health improvers and recruiting helpful insects with insectary plants [86]. "Biodynamic" promotes biodiversity by breeding livestock tailored to each unique farm system, rather than relying on conventional breeds, and by utilizing heirloom seeds for vegetables and heirloom fruit varieties.

"Permaculture" seems to be foremost among the systems for implementations of the sixth ecological principle of the UN, "synergies", because it seeks to connect the disparate living and non-living elements by designing place plant selections that thread them together. It does this by relying on a mix of weed successions, compost, and manure applications, and the plantings of both annual and perennial leguminous crops. It designs plantings that seek to close the vegetal canopy, so it shades the ground completely to preserve soil moisture and mulches plants that accumulate plant beneficial nutrients. It seeks to foster healthier soils to provide the nutrients, water, and soil conditions for supporting a heightened network of relationships between annual and perennial food, forage, and medicinal plantings. It also grows plants with multiple functions, such as plants that prevent erosion, add N, feed people, and provide a habitat for beneficial pest predators, such as birds. Other synergies, such as "permaculture", include growing water-needy plants near downspouts from rooftop rain gutters and constructing water-harvesting swales [86]. "Organic agriculture" fosters synergies with complementary nutrient element provisioning by adding organic materials, such as fertilizers; in turn, the organic matter feeds microbes and develops better soil structure. This also improves water infiltration and drainage and increases water retention [111]. "Regenerative agriculture" forms synergies by integrating crops and livestock [112]. In "biodynamic farming", ritualized recipes of herbs and animal parts are prepared and impact compost with the belief that this helps the compost better help crop growth and soil health. "Carbon farming" contains a structural backbone of perennial crops for multiple functions that both feed people and supply fuel and building material resources, grow perennial livestock feed, and plant complex multi-strata agroforestry systems. These sequester CO_2 on a constant basis from the atmosphere and keep soil life constantly in motion, supplying constant photosynthates to root exudates that feed the soil microbiome. The microbiome then, in turn, sequesters the carbon and turns dead microbial, floral, and faunal decayed biomass into stable C in the form of humus [63]. "Holistic management" promotes synergistic function by managing the grazing of arid and semi-arid grasslands in a way that increases soil carbon through manure and urine depositions into the soil profile and by constantly moving livestock [59].

The seventh UN principle, "economic diversification", is intended to aid small-scale farmers. Although all the systems are explicitly or inexplicitly focused on economic diversification, "permaculture" is designed to provision multiple food crops and is thus in a unique position to provide both food for farmers in less financially secure nations and a greater diversity of cash crops for their markets. This is because its practices include guilds and food forests. These plant groupings grow multiple food-producing tree species and understory plantings that are also edible. Vegetables and ground-hugging berries and other fruits are some of the crops; this widens the availability of different economically sound products [86]. "Biodynamic farming" practices a mix of production sources that contribute naturally to economic diversification. Biodynamic farmers grow polycultures, so if one crop fails, there may be others that survive. Biodynamic farmers also integrate animal agriculture with crops as a further means of economic diversification [97]. "Carbon farming" also promotes the use of multi-strata mixed perennial cropping systems and thus provides a more economically diverse array of food and fiber products [63]. Small-scale multi-cropping and economic diversification is also promoted in "organic farming" [113,114]. "Regenerative farming" practices are also intended to biodiversify life on the farm, both the marketable crops and the cover crops, as well as the livestock. Due to the biodiversification of the cropping systems to enhance C sequestration, regenerative practices seem well suited for economic diversification, particularly for smaller-scale regenerative farmers as

discussed earlier. "Holistic Management" principles emphasize economic diversification by provisioning livestock products for meat, wool, and leather [55].

The eighth UN agroecology principle is "sharing and co-creation of knowledge", yet it is not mentioned by most of the ecological agriculture systems outright. Yet, most of the systems imply this in their principles. For example, "biodynamic farming" practices include seed saving and livestock breeding on farms, and they share their knowledge amongst other biodynamic growers [97]. "Permaculture" practitioners seem to share values and exchange knowledge [115] and have been stated in some of the agronomic literature as functioning, in part, as a transnational community of practice [116]. Similarly, some scholars cite the co-creation of knowledge as increasing in recognition in more recent years by the agroecology movement [117]. Various examples of knowledge sharing in "agroecology" contain models provided in a review [118].

The ninth UN principle of agroecology, "social values and diet", and the tenth principle, "social fairness", are evident in all the ecological agriculture systems in their focus on biodiversity and social justice, as mentioned above. The main difference hinges on how some ecological agriculture systems state these principles succinctly, while others imply them. For example, "regenerative organic" ideals include striving for the implementation of fairness by ensuring that workers receive fair treatment for fair, living wages as one of their mandates [119]. "Biodynamic farming" also includes statements emphasizing Biodynamic Association members to actively plant, cultivate, and nurture diversity, equity, inclusion, and right relationships in their movement and communities [120]. "Permaculture" meets "fairness" through provisioning food justice, a sub-movement within the social justice movement of agroecology. "Permaculture" obligates practitioners to be conscientious of human rights, offering equal chances for all farmers and farm laborers to pursue creative aims in the design, maintenance, and harvest of the "permaculture" systems, irrespective of their social background [121]. Similarly, the emphasis of "agroecology" on human and social values and issues of equity and social justice in food systems have been highlighted as core elements of "agroecology" [122].

For the UN's 11th principle of "connectivity", "organic farming" producers have a long history of small-scale farm management, which often capitalizes on their market produce by selling to consumers at local urban area farmers' markets. In this way, growers get to connect to their consumers directly [123]. "Regenerative agriculture" farmers facilitate connectivity through marketing campaigns and public information provisioning outreach through media, like the documentary film "Kiss The Ground" [124]. "Biodynamic farming" growers commit themselves to connectivity by promoting their produce at local marketplaces and marketing through online websites in the US [97]. "Holistic management" advertises their movement in online media platforms. [59]. "Permaculture" maintains connectivity between producers and consumers by hosting educational programs where students get to learn how to design their own permaculture systems while sustaining themselves off their educational farm experience, e.g., the Hava and Adam Eco-Educational Farm [125]. "Carbon farming" accomplishes connectivity when practiced by growing food forests, helping farmers and laborers to maintain themselves by growing home gardens, which use edible, medicinal, and native species from the rainforest and fostering educational connectivity through the literature [63]. Connectivity in "agroecology farming" systems has also been mentioned [118].

The twelfth principle of the UN's thirteen agroecological principles is "land and natural resource governance". Again, some of the "ecological agriculture" systems mention this principle more explicitly than others. "Carbon farming" probably excels here by its principles of supplying agroforestry systems and implementing perennial cropping systems that endure increasingly extreme weather events [63]. "Permaculture" achieves land governance by implementing a design principle for the architecture of the species on the farmland and their resource provisioning, which eases the process of management and governance on their land [126]. Similarly, "holistic management" strives to enhance land and natural resource governance through exact planning of how resources, both natural

and fiscal, will be implemented, and paying careful attention to the behavior of the herd animals [59].

The thirteenth principle, "participation", plays a central theme in most of the variations of ecological agriculture systems, as mentioned above in their descriptions.

4. Challenges Facing the Implementation of the Ecological Agriculture Systems

Perhaps one of the greatest challenges facing the implementation of the variations of the ecological agriculture systems is the question of whether these systems can feed the growing population of the world. A review of the literature showed that this question is discussed more specifically for "organic agriculture" than the other forms of ecological agriculture [127–129]. Some examples of this same question are directed towards "agroecology" [130], "regenerative agriculture", and "permaculture" as well [131]. Similarly, there are several non-peer-reviewed popular press articles posing the same question to the other ecological agriculture systems. The debate is that as the population increases, high-yielding crop systems will be necessary to feed the world, and some of the ecological agriculture variations may take more time to yield enough to supply the food chain because it takes time for soil to meet the crop nutrients and water requirement with fewer inputs. Some authors state that it may not be possible without adding external fertilizer and irrigation water [132,133]. Meanwhile, arable land is being lost due to urbanization [134] and land degradation processes [135] in many parts of the world. It is estimated that 1.8–2.4% of arable land will be lost globally by 2030, of which approximately 80% will be in Asia and Africa [134]. Furthermore, most of the ecological agriculture systems seek to reduce pesticide use or not use it at all; however, increased pests with climate change will be a challenge [136,137]. Also, some of the ecological agriculture systems discourage tillage and disallow hand weeding or any means of disturbing the soil, e.g., "regenerative" and "regenerative organic farming" [106,138]. This may have implications for weed management.

The inchoate nature of multiple versions of ecological agriculture formed by crossovers between movements and practices pulls farmers in multiple directions, leading farmers to choose the easiest management decisions to implement. This means usually dropping away from adopting ecological practices for other agricultural institutional demands, such as food safety [139]. Also, convincing more farmers to adopt more biodiverse practices is difficult because it increases management, involvement, and labor [140]. Furthermore, multiple crop interactions with different soils on different farms and varied microclimates, regional climates, and surrounding farm organisms all are involved, increasing the complexity [141]. Transformative socio-economic changes [142] and policies [143] will be required for the widespread adoption of methods that promote biodiversity in farms. Lastly, many farmers are resistant to changing practices when they are unable to understand the nuance and complexity of treating their farms like an ecosystem [144].

5. Conclusions

The overarching theme of the various agricultural systems based on ecological principles is very similar in their goals of developing self-sustaining, environmentally friendly, and socially justified production systems. However, each of these systems seems to have a community of adopters and practitioners dedicated to the philosophies and principles of the founders of the systems. These farming systems seem to prefer to identify themselves on their own set of philosophies and the names of their systems. We presented these as "variations of farming systems based on ecological principles" and outlined the similarities and differences between them. These farming systems seem to be community movements that are deeply rooted in their philosophies, and they may be reluctant to abandon their ideas. Meanwhile, it appears that the United Nations' thirteen principles of agroecology attempt to consolidate the principles from the various systems. A farmer considering adopting one of these ecological farming systems could easily become confused. Therefore, we hope that this review helps such farmers consider the similarities and differences between these systems and familiarize themselves with some of the challenges in the implementation of

ecological agriculture systems. Instead of debating which of these systems may be better, we conclude that regardless of what system one decides to adopt, the ultimate overall goal is to meet the future food, feed, and fiber needs of the population without further depleting the limited global resources and/or reversing the adverse effects of agriculture.

Author Contributions: Conceptualization, writing, and editing, A.S.; writing and editing D.H. All authors have read and agreed to the published version of the manuscript.

Funding: The research received no funding.

Data Availability Statement: This is a concept paper and no data is involved.

Conflicts of Interest: The authors declare no conflicts of interest.

References

1. Lam, D. How the world survived the population bomb: Lessons from 50 years of extraordinary demographic history. *Demography* **2011**, *48*, 1231–1262. [CrossRef]
2. McDonald, B.L. The World Food Crisis and the End of the Postwar Food System. In *Food Power: The Rise and Fall of the Postwar American Food System*; Oxford Academic: New York, NY, USA, 2017. [CrossRef]
3. Jachertz, R.; Nützenadel, A. Coping with hunger? Visions of a global food system, 1930–1960. *J. Glob. Hist.* **2011**, *6*, 99–119. [CrossRef]
4. Smil, V. China's great famine: 40 years later. *BMJ* **1999**, *319*, 1619–1621. [CrossRef] [PubMed]
5. Riley, B. *The Political History of American Food Aid: An Uneasy Benevolence*; Oxford University Press: New York, NY, USA, 2017.
6. Pingali, P. Green revolution: Impacts, limits, and the path ahead. *Proc. Natl. Acad. Sci. USA* **2012**, *109*, 12302–12308. [CrossRef]
7. Nelson, A.R.L.E.; Ravichandran, K.; Antony, U. The impact of the green revolution on indigenous crops of India. *J. Ethnic Foods* **2019**, *6*, 8. [CrossRef]
8. Pinstrup-Andersen, P.; Hazell, P.B.R. The impact of the green revolution and prospects for the future. *Food Rev. Int.* **1985**, *1*, 1–25. [CrossRef]
9. Wu, F.; Butz, W.P. The Green Revolution. In *The Future of Genetically Modified Crops: Lessons from the Green Revolution*, 1st ed.; RAND Corporation: Santa Monica, CA, USA, 2004; pp. 11–38. Available online: http://www.jstor.org/stable/10.7249/mg161rc.11 (accessed on 28 December 2023).
10. Davies, W.P. An Historical Perspective from the Green Revolution to the Gene Revolution. *Nutr. Rev.* **2003**, *61*, S124–S134. [CrossRef] [PubMed]
11. Pingali, P. Are the Lessons from the Green Revolution Relevant for Agricultural Growth and Food Security in the Twenty-First Century? In *Agricultural Development in Asia and Africa*; Estudillo, J.P., Kijima, Y., Sonobe, T., Eds.; Emerging-Economy State and International Policy Studies; Springer: Singapore, 2023. [CrossRef]
12. Jackson, W.; Piper, J. The necessary marriage between ecology and agriculture. *Ecology* **1989**, *70*, 1091–1993. [CrossRef]
13. Tilman, D.; Cassman, K.; Matson, P.; Naylor, R.; Polasky, S. Agricultural sustainability and intensive production practices. *Nature* **2002**, *418*, 671–677. [CrossRef]
14. Magdoff, F. Ecological agriculture: Principles, Practices, and Constraints. *Renew. Agric. Food Syst.* **2007**, *22*, 109–117. [CrossRef]
15. Dale, V.H.; Brown, S.; Haeuber, R.A.; Hobbs, N.T.; Huntly, N.; Naiman, R.J.; Riebsame, W.E.; Turner, M.G.; Valone, T.J. Ecological principles and guidelines for managing the use of land. *Ecol. Appl.* **2000**, *10*, 639–670. [CrossRef]
16. Pretty, J. Agricultural sustainability: Concepts, principles and evidence. *Phil. Trans. R. Soc. B* **2008**, *363*, 447–465. [CrossRef] [PubMed]
17. Robertson, G.P.; Swinton, S.M. Reconciling agricultural productivity and environmental integrity: A grand challenge for agriculture. *Front. Ecol. Environ.* **2005**, *33*, 8–46. [CrossRef]
18. John, D.A.; Babu, G.R. Lessons from the aftermaths of green revolution on food system and health. *Front. Sustain. Food Syst.* **2021**, *5*, 644559. [CrossRef]
19. Horrigan, L.; Lawrence, R.S.; Walker, P. How sustainable agriculture can address the environmental and human health harms of industrial agriculture. *Environ. Health Perspect.* **2002**, *110*, 445–456. [CrossRef] [PubMed]
20. Kremen, C.; Miles, A. Ecosystem services in biologically diversified versus conventional farming systems: Benefits, externalities, and trade-offs. *Ecol. Soc.* **2012**, *17*, 4. Available online: http://www.jstor.org/stable/26269237 (accessed on 30 December 2023). [CrossRef]
21. Wezel, A.; Herren, B.G.; Kerr, R.B.; Barrios, E.; Gonçalves, A.L.R.; Sinclair, F. Agroecological principles and elements and their implications for transitioning to sustainable food systems. A review. *Agron. Sustain. Dev.* **2020**, *40*, 40. [CrossRef]
22. Pimentel, D.; Pimentel, M. Comment: Adverse Environmental Consequences of the Green Revolution. *Popul. Dev. Rev.* **1990**, *16*, 329–332. [CrossRef]
23. Porter, S.S.; Sachs, J.L. Agriculture and the disruption of plant-microbial symbiosis. *Trends Ecol. Evol.* **2020**, *35*, 426–439. [CrossRef]
24. Dixon, M.; Rohrbaugh, C.; Afkairin, A.; Vivanco, J. Impacts of the green revolution on rhizosphere microbiology related to nutrient acquisition. *Appl. Microbiol.* **2022**, *2*, 992–1003. [CrossRef]

25. Harwood, J. Could the adverse consequences of the green revolution have been foreseen? How experts responded to unwelcome evidence. *Agroecol. Sustain. Food Syst.* **2020**, *44*, 509–535. [CrossRef]
26. Pingali, P.L.; Rosegrant, M.W. Confronting the environmental consequences of the green revolution in Asia. In *Environment and Production Technology Division Discussion Paper No. 2*; International Food Policy Research Institute: Washington, DC, USA, 1994. Available online: https://ebrary.ifpri.org/utils/getfile/collection/p15738coll2/id/125528/filename/125559.pdf (accessed on 30 December 2023).
27. Conway, G.R.; Barbie, E.B. After the Green Revolution: Sustainable and equitable agricultural development. *Futures* **1988**, *20*, 651–670. [CrossRef]
28. Sustainable Agriculture. Available online: https://www.nal.usda.gov/farms-and-agricultural-production-systems/sustainable-agriculture (accessed on 3 May 2024).
29. Gliessman, S.R. 3 Sustainable agriculture: An agroecological perspective. *Adv. Plant Pathol.* **1995**, *11*, 45–57. [CrossRef]
30. Gliessman, S.R. Agroecology and Agroecosystems. In *Agroecosystems Analysis, Agronomy Monographs 43*; Diane, R., Francis, C., Eds.; American Society of Agronomy, Inc.; Crop Science Society of America, Inc.; Soil Science Society of America, Inc.: Madison, WI, USA, 2004; pp. 19–29. Available online: https://acsess.onlinelibrary.wiley.com/doi/abs/10.2134/agronmonogr43.c2 (accessed on 30 December 2023).
31. León-Sicard, T.E.; Toro Calderón, J.; Martínez-Bernal, L.F.; Cleves-Leguízamo, J.A. The main agroecological structure (MAS) of the agroecosystems: Concept, methodology and applications. *Sustainability* **2018**, *10*, 3131. [CrossRef]
32. Klages, K.H. Crop ecology and ecological crop geography in the agronomic curriculum. *J. Am. Soc. Agron.* **1928**, *20*, 336–353. [CrossRef]
33. Pimbert, M.; Moeller, N.; Singh, J.; Anderson, C. Agroecology. Oxford Research Encyclopedia of Anthropology. 2021. Available online: https://oxfordre.com/anthropology/view/10.1093/acrefore/9780190854584.001.0001/acrefore-9780190854584-e-298 (accessed on 30 December 2023).
34. Bensin, B.M. *Agroecological Characteristics Description and Classification of the Local Corn Varieties-Chorotypes*. 1928. Available online: https://books.google.co.th/books?id=AffJtgAACAAJ (accessed on 30 December 2023).
35. Altieri, M.A. *Agroecology the Scientific Basis of Alternative Agriculture*; Intermediate Publications: London, UK, 1987; pp. 45–48.
36. Gliessman, S.R. Agroecology: Researching the Ecological Basis for Sustainable Agriculture. In *Agroecology*; Gliessman, S.R., Ed.; Ecological Studies; Springer: New York, NY, USA, 1990; Volume 78. [CrossRef]
37. Thomas, V.G.; Kevan, P.G. Basic principles of agroecology and sustainable agriculture. *J. Agric. Environ. Ethics* **1993**, *6*, 1–19. [CrossRef]
38. Francis, C.; Lieblein, G.; Gliessman, S.R.; Breland, T.A.; Creamer, N.; Salomonsson, L.; Helenius, J.; Rickerl, D.; Salvador, R.; Wiedenhoeft, M.; et al. Agroecology: The ecology of food systems. *J. Sustain. Agric.* **2003**, *22*, 99–118. [CrossRef]
39. Wezel, A.; Bellon, S.; Doré, T.; Francis, C.; Vallod, D.; David, C. Agroecology as a science, a movement and a practice: A review. *Agron. Sustain. Dev.* **2009**, *29*, 503–515. [CrossRef]
40. De Molina, G.M.; Petersen, P.F.; Peña, F.P.; Caporal, F.R. *Political Agroecology: Advancing the Transition to Sustainable Food Systems*; CRC Press: Boca Raton, FL, USA, 2019.
41. Anderson, C.; Bruil, J.; Chappell, M.J.; Kiss, C.; Pimbert, M.P. *Agroecology Now! Transformations Towards More Just and Sustainable Food Systems*; Palgrave Pivot Series: London, UK, 2020.
42. Gliessman, S. Defining Agroecology. *Agroecol. Sustain. Food Syst.* **2018**, *42*, 599–600. [CrossRef]
43. Food and Agriculture Organization (FAO). The 10 Elements of Agroecology: Guiding the Transition to Sustainable Food and Agricultural Systems. 2018. Available online: https://www.fao.org/documents/card/en/c/I9037EN/ (accessed on 23 March 2024).
44. Rosset, P.M.; Martínez-Torres, M.E. Rural social movements and agroecology: Context, theory, and process. *Ecol. Soc.* **2012**, *17*, 17. Available online: https://www.jstor.org/stable/26269097 (accessed on 2 April 2024). [CrossRef]
45. Acevedo-Osorio, Á.; Chohan, J.K. Agroecology as social movement and practice in Cabrera's peasant reserve zone, Colombia. *Agroecol. Sustain. Food Syst.* **2020**, *44*, 331–351. [CrossRef]
46. van den Berg, L.; Teixeira, H.M.; Behagel, J.H.; Verschoor, G.; Turnhout, E.; Cardoso, I.M.; Botelho, M.I.V. From managing transitions towards building movements of affect: Advancing agroecological practices and transformation in Brazil. *Geoforum* **2022**, *131*, 50–60. [CrossRef]
47. Rodale, R. Breaking new ground: The search for a sustainable agriculture. *Futurist* **1983**, *1*, 15–20.
48. Schreefel, L.; Schulte, R.P.O.; de Boer, I.J.M.; Pas Schrijver, A.; van Zanten, H.H.E. Regenerative agriculture—The soil is the base. *Glob. Food Secur.* **2020**, *26*, 100404. [CrossRef]
49. Newton, P.; Civita, N.; Frankel-Goldwater, L.; Bartel, K.; Johns, C. What is regenerative agriculture? A review of scholar and practitioner definitions based on processes and outcomes. *Front. Sustain. Food Syst.* **2020**, *4*, 577723. [CrossRef]
50. Iowa Soybean Association. Regenerative Ag: A Systems Approach to Soil Health. 2021. Available online: https://www.iasoybeans.com/newsroom/article/isr-regenerative-ag-a-systems-approach-to-soil-health (accessed on 3 May 2024).
51. Regeneration International. Why Regenerative Agriculture. Available online: https://regenerationinternational.org/why-regenerative-agriculture/ (accessed on 3 May 2024).
52. California Department of Food and Agriculture. Defining Regenerative Agriculture for State Policies and Programs. Available online: https://www.cdfa.ca.gov/RegenerativeAg/ (accessed on 3 May 2024).

53. Food and Agriculture Organization of the United Nations. Regenerative Agriculture: Good Practices for Small Scale Agricultural Producers. 2020. Available online: https://www.fao.org/documents/card/en?details=CB6018EN/ (accessed on 3 May 2024).
54. Syngenta Group. Regenerative Agriculture. Available online: https://www.syngentagroup.com/regenerative-agriculture (accessed on 3 May 2024).
55. Tittonell, P.; El Mujtar, V.; Felix, G.; Kebede, Y.; Laborda, L.; Soto, R.L.; de Vente, J. Regenerative agriculture—Agroecology without politics? *Front. Sustain. Food Syst.* **2022**, *6*, 844261. [CrossRef]
56. Nordborg, N. *Holistic Management—A Critical Review of Alan Savory's Grazing Method*; SLU/EPOK—Centre for Organic Food & Farming & Chalmers, Swedish University of Agricultural Sciences & Chalmers: Uppsala, Sweden, 2016; 45p.
57. Gosnell, H.; Grimm, K.; Goldstein, B.E. A half century of holistic management: What does the evidence reveal? *Agric. Hum. Val.* **2020**, *37*, 849–867. [CrossRef]
58. Fairlie, S. *Meat: A Benign Extravagance*; Chelsea Green Publishing: White River Junction, VT, USA, 2010; pp. 191–193.
59. Savory, A. A Framework for Managing Complexity. Available online: https://savory.global/holistic-management/ (accessed on 3 May 2024).
60. Lal, R. Carbon farming by recarbonization of agroecosystems. *Pedosphere* **2023**, *33*, 676–679. [CrossRef]
61. Lal, R. Abating climate change and feeding the world through soil carbon sequestration. In *Soil as World Heritage*; Dent, D., Ed.; Springer: Dordrecht, The Netherlands, 2013; pp. 443–457. [CrossRef]
62. European Commission. Commission Staff Working Document. Sustainable Carbon Cycles—Carbon Farming Accompanying the Communication from the Commission to the European Parliament and the Council Sustainable Carbon Cycles, SWD/2021/450 Final. Available online: https://op.europa.eu/en/publication-detail/-/publication/d1d1329f-5d8e-11ec-9c6c-01aa75ed71a1/language-en (accessed on 29 March 2024).
63. Toensmeier, E. *The Carbon Farming Solution: A Global Toolkit of Perennial Crops and Regenerative Agriculture Practices for Climate Change Mitigation and Food Security*; Chelsea Green Publishing: White River Junction, VT, USA, 2016; 512p.
64. Jansson, C.; Faiola, C.; Wingler, A.; Zhu, X.-G.; Kravchenko, A.; de Graaff, M.-A.; Ogden, A.J.; Handakumbura, P.P.; Werner, C.; Beckles, D.M. Crops for Carbon Farming. *Front. Plant Sci.* **2021**, *12*, 636709. [CrossRef]
65. Nair, P.K.R.; Nair, V.D.; Mohan Kumar, B.; Showalter, J.M. Chapter 5—Carbon sequestration in agroforestry systems. *Adv. Agron.* **2010**, *108*, 237–307.
66. Chatterjee, N.; Nair, P.K.R.; Chakraborty, S.; Nair, V.D. Changes in soil carbon stocks across the forest-agroforest-agriculture/pasture continuum in various agroecological regions: A meta-analysis. *Agric. Ecosyst. Environ.* **2018**, *266*, 55–67. [CrossRef]
67. Lal Carbon Center. Carbon Farming Alliance for Research and Management (C-FARM). Available online: https://carbon.osu.edu/c-farm (accessed on 4 May 2024).
68. USDA. Report to Congress: A General Assessment of the Role of Agriculture and Forestry in U.S. Carbon Markets. 2023. Available online: https://www.usda.gov/sites/default/files/documents/USDA-General-Assessment-of-the-Role-of-Agriculture-and-Forestry-in-US-Carbon-Markets.pdf (accessed on 4 May 2024).
69. Green America. Agriculture and Climate Change. Available online: https://www.greenamerica.org/food-climate/what-carbon-farming (accessed on 4 May 2024).
70. Bayer, ForGround. Available online: https://bayerforground.com/carbon-initiative (accessed on 3 March 2024).
71. National Corn Growers Association. Carbon Markets. Available online: https://ncga.com/key-issues/other-topics/carbon-markets (accessed on 4 March 2024).
72. Raina, N.; Zavalloni, M.; Viaggi, D. Incentive mechanisms of carbon farming contracts: A systematic mapping study. *J. Environ. Manag.* **2024**, *352*, 120126. [CrossRef]
73. Barbato, C.T.; Strong, A.L. Farmer perspectives on carbon markets incentivizing agricultural soil carbon sequestration. *NPJ Clim. Action* **2023**, *2*, 26. [CrossRef]
74. Paull, J. The Betteshanger Summer School: Missing link between biodynamic agriculture and organic farming. *J. Org. Syst.* **2011**, *6*, 14–18.
75. Adamchak, R. Organic Farming. *Encyclopedia Britannica*, 27 March 2024. Available online: https://www.britannica.com/topic/organic-farming (accessed on 30 March 2024).
76. Kuepper, G. *A Brief Overview of the History and Philosophy of Organic Agriculture*; Kerr Center for Sustainable Agriculture: Poteau, OK, USA, 2010. Available online: https://kerrcenter.com/wp-content/uploads/2014/08/organic-philosophy-report.pdf (accessed on 30 March 2024).
77. Northbourne, L. *Look to the Land*; J. M. Dent: London, UK, 1940.
78. Walksman, S.A. *Humus. Origin, Chemical Composition and Importance Nature*; Williams and Wilkins: New York, NY, USA, 1936.
79. Visser, S.A. Effects of humic substances on plant growth. In *Humic Substances: Effects on Soil and Plants*; Burns, R.G., Dell'Agnola, G., Miele, S., Nardi, S., Savoini, G., Schnitzer, M., Sequi, P., Vaughan, D., Visser, S., Eds.; Ramo Editoriale degli Agricoltori: Rome, Italy, 1986; pp. 89–135.
80. Calvo, P.; Nelson, L.; Kloepper, J.W. Agricultural uses of plant biostimulants. *Plant Soil.* **2014**, *383*, 3–41. [CrossRef]
81. Kasper, M.; Freyer, B.; Hülsbergen, K.; Schmid, H.; Friedel, J. Humus balances of different farm production systems in main production areas in Austria. *J. Plant Nutr. Soil Sci.* **2014**, *178*, 25–34. [CrossRef]

82. Chatzistathis, T.; Kavvadias, V.; Sotiropoulos, T.; Papadakis, I.E. Organic Fertilization and Tree Orchards. *Agriculture* **2021**, *11*, 692. [CrossRef]
83. FAO. *Organic Agriculture*; Food and Agriculture Organization of the United Nations: Rome, Italy, 1999. Available online: http://www.fao.org/unfao/bodies/COAG/COAG15/X0075E.htm (accessed on 1 April 2024).
84. USDA. Introduction to Organic Practices. 2015. Available online: https://www.ams.usda.gov/sites/default/files/media/Organic%20Practices%20Factsheet.pdf (accessed on 4 May 2024).
85. Luttikholt, L.W.M. Principles of organic agriculture as formulated by the International Federation of Organic Agriculture Movements. *NJAS—Wagen. J. Life Sci.* **2007**, *54*, 347–360. Available online: https://www.sciencedirect.com/science/article/pii/S157352140780008X (accessed on 3 March 2024). [CrossRef]
86. Hemenway, T. *Gaia's Garden: A Guide to Home-scale Permaculture*; Chelsea Green Publishing: White River Junction, VT, USA, 2009; 328p.
87. Holmgren, D. Essence of Permaculture. In *Permaculture: Principles & Pathways Beyond Sustainability*; Holmgren Design Services: Melbourne, Australia, 2007. Available online: https://www.transitionmonty.org/uploads/6/5/4/9/6549206/essence_of_pc_ebook_1.pdf (accessed on 3 March 2024).
88. Krebs, J.; Bach, S. Permaculture—Scientific evidence of principles for the agroecological design of farming systems. *Sustainability* **2018**, *10*, 3218. [CrossRef]
89. Kutschera, U. Ernst Haeckel's biodynamics 1866 and the occult basis of organic farming. *Plant Signal Behav.* **2016**, *11*, e1199315. [CrossRef]
90. Reganold, J.P.; Wachter, J.M. Organic agriculture in the twenty-first century. *Nat. Plants* **2016**, *2*, 15221. [CrossRef]
91. Santoni, M.; Ferretti, L.; Migliorini, P.; Vazzana, C.; Pacini, G.C. A review of scientific research on biodynamic agriculture. *Org. Agric.* **2022**, *12*, 373–396. [CrossRef]
92. Lejano, R.; Ingram, M.; Ingram, H.M. Narratives of Nature and Science in Alternative Farming Networks. In *Power of Narrative in Environmental Networks*; MIT Press: Cambridge, MA, USA, 2013; p. 155.
93. Paull, J. Attending the first organic agriculture course: Rudolf Steiner's agriculture course at Koberwitz, 1924. *Eur. J. Soc. Sci.* **2011**, *21*, 64–70.
94. Chalker-Scott, L. The science behind biodynamic preparations: A literature review. *HortTechnology* **2013**, *23*, 814–819. [CrossRef]
95. Rigolot, C.; Quantin, M. Biodynamic farming as a resource for sustainability transformations: Potentials and challenges. *Agric. Syst.* **2022**, *200*, 103424. [CrossRef]
96. Muhie, S.H. Concepts, principles, and application of biodynamic farming: A review. *Circ. Econ. Sustainability.* **2023**, *3*, 291–304. [CrossRef]
97. Biodynamic Demeter Alliance. Biodynamic Principles and Practices. Available online: https://www.biodynamics.com/biodynamic-principles-and-practices (accessed on 4 May 2024).
98. USDA Organic. US Department of Agriculture. Available online: https://www.usda.gov/topics/organic (accessed on 4 May 2024).
99. Food and Agriculture Organization of the United Nations. Conservation Agriculture. Available online: https://www.fao.org/conservation-agriculture/en/ (accessed on 4 May 2024).
100. Hobbs, P.R.; Sayre, K.; Gupta, R. The role of conservation agriculture in sustainable agriculture. *Phil. Trans R. Soc. B* **2008**, *363*, 543–555. [CrossRef]
101. Li, Y.; Chang, S.X.; Tian, L.; Zhang, Q. Conservation agriculture practices increase soil microbial biomass carbon and nitrogen in agricultural soils: A global meta-analysis. *Soil Biol. Biochem.* **2018**, *121*, 50–58. [CrossRef]
102. Abdalla, M.; Osborne, B.; Lanigan, G.; Forristal, D.; Williams, M.; Smith, P.; Jones, M.B. Conservation tillage systems: A review of its consequences for greenhouse gas emissions. *Soil Use Manag.* **2013**, *29*, 199–209. [CrossRef]
103. Cordeau, S.; Gatere, L.; Jat, M.L.; Pittelkow, C.M.; Thierfelder, C. Editorial: Conservation agriculture: Knowledge frontiers around the world. *Front. Agron.* **2023**, *5*, 1177412. [CrossRef]
104. Tufa, A.H.; Kanyamuka, J.S.; Alene, A.; Ngoma, H.; Marenya, P.P.; Thierfelder, C.; Banda, H.; Chikoye, D. Analysis of adoption of conservation agriculture practices in southern Africa: Mixed-methods approach. *Front. Sustain. Food Syst.* **2023**, *7*, 1151876. [CrossRef]
105. Ngoma, H.; Angelsen, A.; Jayne, T.S.; Chapoto, A. Understanding adoption and impacts of conservation agriculture in eastern and southern Africa: A review. *Front. Agron.* **2021**, *3*, 671690. [CrossRef]
106. Regenerative Organic. Regenerative Organic Alliance. [Archived]. 2024. Available online: https://regenorganic.org (accessed on 3 March 2024).
107. Norris, K. Agriculture and biodiversity conservation: Opportunity knocks. *Conserv. Lett.* **2008**, *1*, 2–11. [CrossRef]
108. Feber, R.E.; Johnson, P.J.; Chamberlain, D.E.; Firbank, L.G.; Fuller, R.J.; Hart, B.; Manley, W.; Mathews, F.; Norton, L.R.; Townsend, M.; et al. Does organic farming affect biodiversity? In *Wildlife Conservation on Farmland Volume 1: Managing for Nature on Lowland Farms*; Macdonald, D.W., Feber, R.E., Eds.; Oxford Academic: Oxford, UK, 2015. Available online: https://academic.oup.com/book/26851/chapter-abstract/195873162?redirectedFrom=fulltext (accessed on 3 March 2024).
109. Reinhard, J.E.; Geissler, K.; Blaum, N. Grass and ground dwelling beetle community responses to holistic and wildlife grazing management using a cross-fence comparison in Western Kalahari rangeland, Namibia. *J. Insect Conserv.* **2022**, *26*, 711–720. [CrossRef]

110. Frac, M.; Panek, J.; Gryta, A.; Oszust, K.; Pertile, G.; Siegieda, D.; Mącik, M.; Pylak, M.; Imran Pathan, S.; Pietramellara, G. Legume-cereal intercropping as a strategy of regenerative agriculture supporting reverse of biodiversity loss-relevance of microbiome-based research. In *ARPHA Conference Abstracts*; Pensoft Publishers: Sofia, Bulgaria, 2023; Volume 6, p. e108886. [CrossRef]
111. Richardson, A.E.; Coonan, E.; Kirkby, C.; Orgill, S. Soil organic matter and carbon sequestration. In *Australian Agriculture in 2020: From Conservation to Automation*; Pratley, J., Kirkegaard, J., Eds.; Australian Society of Agronomy: Willow Grove, Australia, 2019; pp. 255–271. Available online: http://agronomyaustraliaproceedings.org/index.php/special-publications (accessed on 19 May 2024).
112. Sekaran, U.; Lai, L.; Ussiri, D.A.; Kumar, S.; Clay, S. Role of integrated crop-livestock systems in improving agriculture production and addressing food security–A review. *J. Agric. Food Res.* **2021**, *5*, 100190. [CrossRef]
113. Seufert, V.; Austin, S.E.; Badami, M.G.; Turner, S.; Ramankutty, N. The diversity of organic farmer motivations and livelihoods in the Global South–A case study in Kerala, India. *Geoforum* **2023**, *138*, 103670. [CrossRef]
114. Jouzi, Z.; Azadi, H.; Taheri, F.; Zarafshani, K.; Gebrehiwot, K.; Van Passel, S.; Lebailly, P. Organic Farming and Small-Scale Farmers: Main Opportunities and Challenges. *Ecol. Econ.* **2016**, *132*, 144–154. [CrossRef]
115. Ingram, J.; Maye, D.; Kirwan, J.; Curry, N.; Kubinakova, K. Learning in the permaculture community of practice in England: An analysis of the relationship between core practices and boundary processes. *J. Agric. Educ. Ext.* **2014**, *3*, 275–290. [CrossRef]
116. Habib, B.; Fadaee, S. Permaculture: A global community of practice. *Environ. Values* **2022**, *31*, 441–462. [CrossRef]
117. Utter, A.; White, A.; Ernesto Méndez, V.; Morris, K. Co-creation of knowledge in agroecology. *Elementa Sci. Anthrop.* **2021**, *9*, 00026. [CrossRef]
118. Nimmo, E.R.; Nelson, E.; Gómez-Tovar, L.; García, M.M.; Spring, A.; Lacerda, A.E.B.; de Carvalho, A.I.; Blay-Palmer, A. Building an agroecology knowledge network for agrobiodiversity conservation. *Conservation* **2023**, *3*, 491–508. [CrossRef]
119. Regenerative Organic Certified® 2023. Framework for Regenerative Organic Certified®. Available online: https://regenorganic.org/wp-content/uploads/2023/03/Regenerative-Organic-Certified-Framework.pdf (accessed on 7 April 2024).
120. Biodynamic Principles and Practices. Biodynamic Association. 2018. Available online: https://www.biodynamics.com/biodynamics-social-justice (accessed on 7 April 2024).
121. Luna, J.M.; Dávila, E.R.; Reynoso-Morris, A. Pedagogy of permaculture and food justice. *Educ. Found.* **2018**, *31*, 57–85.
122. Kerr, R.B.; Liebert, J.; Kansanga, M.; Kpienbaareh, D. Human and social values in agroecology: A review. *Elem. Sci. Anthrop.* **2022**, *10*, 00090. [CrossRef]
123. Kennedy, N. Farm to Table: A Journey of Freshness and Trust. The Farming Insider. 2024. Available online: https://thefarminginsider.com/farm-to-table-journey/ (accessed on 7 April 2024).
124. Kiss the Ground. 2020. Available online: https://kissthegroundmovie.com/ (accessed on 7 April 2024).
125. Hava and Adam Eco-Educational Farm. Available online: https://ecoisrael.org.il/curriculum/ (accessed on 7 April 2024).
126. Permaculture Association. Land Tenure and Community Governance. Available online: https://www.permaculture.org.uk/practical-solutions/land-tenure-and-community-governance (accessed on 7 April 2024).
127. Badgley, C.; Perfecto, I. Can organic agriculture feed the world? *Renew. Agric. Food Syst.* **2007**, *22*, 80–85. [CrossRef]
128. Muller, A.; Schader, C.; El-Hage Scialabba, N.; Brüggemann, J.; Isensee, A.; Erb, K.; Smith, P.; Klocke, P.; Leiber, F.; Stolze, M.; et al. Strategies for feeding the world more sustainably with organic agriculture. *Nat. Commun.* **2017**, *8*, 1290. [CrossRef] [PubMed]
129. Jordan, C.F. Can Organic Agriculture Feed the World? In *Evolution from a Thermodynamic Perspective*; Springer: Cham, Switzerland, 2022. [CrossRef]
130. Kerr, R.B.; Madsen, S.; Stüber, M.; Liebert, J.; Enloe, S.; Borghino, N.; Parros, P.; Mutyambai, D.M.; Prudhon, M.; Wezel, A. Can agroecology improve food security and nutrition? A review. *Glob. Food Secur.* **2021**, *29*, 100540. [CrossRef]
131. Rhodes, C.J. Feeding and healing the world: Through regenerative agriculture and permaculture. *Sci. Prog.* **2012**, *95*, 345–446. [CrossRef] [PubMed]
132. Giller, K.E.; Hijbeek, R.; Andersson, J.A.; Sumberg, J. Regenerative agriculture: An agronomic perspective. *Outlook Agric.* **2021**, *50*, 13–25. [CrossRef] [PubMed]
133. McGuire, A.D.; Lawrence, D.M.; Koven, C.; Clein, J.S.; Burke, E.; Chen, G.; Jafarov, E.; MacDougall, A.H.; Marchenko, S.; Nicolsky, D.; et al. Dependence of the evolution of carbon dynamics in the northern permafrost region on the trajectory of climate change. *Proc. Natl. Acad. Sci. USA* **2018**, *115*, 3882–3887. [CrossRef]
134. Bren d'Amour, C.; Reitsma, F.; Baiocchi, G.; Barthel, S.; Güneralp, B.; Erb, K.; Haberi, H.; Creutzig, F. Future urban land expansion and implications for global croplands. *Proc. Natl. Acad. Sci. USA* **2016**, *114*, 8939–8944. [CrossRef]
135. Prăvălie, R.; Patriche, C.; Borrelli, P.; Panagos, P.; Roșca, B.; Dumitraşcu, M.; Nita, I.; Săvulescu, I.; Birsan, M.; Bandoc, G. Arable lands under the pressure of multiple land degradation processes. A global perspective. *Environ. Res.* **2021**, *194*, 10697. [CrossRef] [PubMed]
136. Skendžić, S.; Zovko, M.; Živković, I.P.; Lešić, V.; Lemić, D. The impact of climate change on agricultural insect pests. *Insects* **2021**, *12*, 440. [CrossRef] [PubMed]
137. Schneider, L.; Rebetez, M.; Rasmann, S. The effect of climate change on invasive crop pests across biomes. *Curr. Opin. Insect Sci.* **2022**, *50*, 100895. [CrossRef] [PubMed]
138. Regenerative Agriculture 101. Available online: https://www.nrdc.org/stories/regenerative-agriculture-101#what-is (accessed on 3 March 2024).

139. Baur, P. When farmers are pulled in too many directions: Comparing institutional drivers of food safety and environmental sustainability in California agriculture. *Agric. Hum. Values* **2020**, *37*, 1175–1194. [CrossRef]
140. Daum, T.; Baudron, F.; Birner, R.; Qaim, M.; Grass, I. Addressing agricultural labour issues is key to biodiversity-smart farming. *Biol. Conserv.* **2023**, *284*, 110165. [CrossRef]
141. Cozim-Melges, F.; Ripoll-Bosch, R.; Veen, G.F.; Oggiano, P.; Bianchi, F.J.J.A.; van der Putten, W.H.; van Zanten, H.H.E. Farming practices to enhance biodiversity across biomes: A systematic review. *NPJ Biodivers.* **2024**, *3*, 1. [CrossRef]
142. Kremen, C. Ecological intensification and diversification approaches to maintain biodiversity, ecosystem services and food production in a changing world. *Emerg. Top. Life Sci.* **2020**, *4*, 229–240. [CrossRef] [PubMed]
143. Brussaard, L.; Caron, P.; Campbell, B.; Lipper, L.; Mainka, S.; Rabbinge, R.; Babin, D.; Pulleman, M. Reconciling biodiversity conservation and food security: Scientific challenges for new agriculture. *Curr. Opin. Environ. Sustain.* **2010**, *2*, 34–42. [CrossRef]
144. Coquil, X.; Cerf, M.; Auricoste, C.; Joannon, A.; Barcellini, F.; Cayre, P.; Chizallet, M.; Dedieu, B.; Hostiou, N.; Hellec, F.; et al. Questioning the work of farmers, advisors, teachers and researchers in agro-ecological transition. A review. *Agron. Sustain. Dev.* **2018**, *38*, 47. [CrossRef]

Disclaimer/Publisher's Note: The statements, opinions and data contained in all publications are solely those of the individual author(s) and contributor(s) and not of MDPI and/or the editor(s). MDPI and/or the editor(s) disclaim responsibility for any injury to people or property resulting from any ideas, methods, instructions or products referred to in the content.