Current Journal of Applied Science and Technology

Volume 42, Issue 14, Page 12-23, 2023; Article no.CJAST.99810
ISSN: 2457-1024
(Past name: British Journal of Applied Science & Technology, Past ISSN: 2231-0843, NLM ID: 101664541)

A Vision toward Regenerative Organic Agriculture to Sustain Climate Change and Combat Global Warming

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Authors' contributions

This work was carried out in collaboration among all authors. All authors read and approved the final manuscript.

Article Information

DOI: 10.9734/CJAST/2023/v42i144117

Open Peer Review History:
This journal follows the Advanced Open Peer Review policy. Identity of the Reviewers, Editor(s) and additional Reviewers, peer review comments, different versions of the manuscript, comments of the editors, etc are available here: https://www.sdiarticle5.com/review-history/99810

Review Article

Received: 21/03/2023
Accepted: 24/05/2023
Published: 03/06/2023

ABSTRACT

Regenerative Agriculture (RA) could be considered as a part of acquiring and maintaining sustainability. RA depends on Sustainable Development Goals (SDGs) for functioning and enhancements related to all kinds of natural resources. The existence of Air and Water Quality Acts and capitalizing on the benefits of the soil-water-air nexus depends on implementing a "Soil Quality Act". The rate of the annual increase in soil C is only transient, even if soil organic matter rises as a result of better management. The rate of carbon accumulation slows as a new equilibrium is reached. Under cultivation at a lower level than a natural vegetative cover. Most intergovernmental panel on climate change (Intergovernmental Panel on Climate Change) scenarios incorporate net-negative emission technologies to maintain global warming to a maximum of 1.5°C, over pre-industrial levels given present trends in greenhouse gas emissions. Vermicompost has proven to be a "miracle plant growth enhancer". It promotes 30-40% over chemical and organic fertilizers and

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protects plants from pests and diseases. Studies have shown that composting earthworm waste significantly reduces total greenhouse gas emissions in the form of CO_2 equivalents, especially nitrous oxide (N2O), which is 296-310 times greenhouse gas than CO_2. The study showed that the vermicomposting system emitted an average of 463 CO_2-e/m^2/h. This is significantly less than the landfill emissions of 3640 CO_2-e /m^2 /h. Vermicomposting released at least N_2O – 1.17 mg/m^2/h compared to aerobic and anaerobic compost (1.48 and 1.59 mg/m^2/h, respectively). Therefore, earthworms can play a good role in greenhouse gas reduction and mitigation strategies in municipal solid waste disposal. Organic systems show a nearly 30% increase in soil carbon over 27 years.

Keywords: Organic agriculture; climate change; global warming; greenhouse gas.

1. INTRODUCTION

The idea that the world food system is "broken" or "in crisis" is becoming more prevalent [1,2]. “Nowadays, every aspect of farming and food production, distribution, and consumption is being questioned, and the current interest in 'Regenerative Agriculture; RA' and 'Regenerative Farming; RF' has taken root” [3].

Fig. 1 illustrates that although the use of these terms in novels first peaked in the mid-late 1980s, by the mid-2000s they had all but vanished. Following 2015, the RA prevalence expanded sharply. It is significant to observe that RA appears in books far less frequently than other phrases like Sustainable Agriculture, Organic Agriculture, Organic Farming, and Agroecology between 1972 and 2018. There isn't a consensus on any one definition of "regenerative agriculture; RA" despite the recent increase in interest in the topic [4,5]. It is unclear whether RA serves as a means or an aim in and of itself. Many definitions of RA, as noted by [6], emphasize the idea of "enhancement," in soil organic matter (SOM) and soil biodiversity [7] biodiversity, soils, watersheds, and ecosystem services [8]; biodiversity and the amount of biomass [9]; and soil health [10]. “Despite the potential genetic engineering offers to bestow plant resistance and lessen the need for chemical sprays, certain interpretations of RA are vehemently anti- Genetically Modifies Organisms (anti- GMO)” [11,12].

Regenerative agriculture is a term that is still relatively new and does not have a strict definition; rather, it refers to a farming concept with "no-size-fits-all" and is a system-specific, holistic approach that is necessary to accomplish Sustainable Development Goals [13]. The idea of sustainable agriculture emerged as an essential strategy to resist the detrimental effects of climate change on agriculture and as a means of bolstering food security for the growing world population without damaging the environment [14]. Global policymakers worked with scientists and thought leaders to develop plans for the Sustainable Development Goals (SDG), which were presented by researchers from all over the world who claimed that conventional farming methods would deplete all significant natural resources, including land, water, and air [15].

2. A PATH TOWARDS SUSTAINABILITY

Regenerative organic farming is a concept that seeks to restore soil and maintain its productivity to prevent extending to new areas at the price of forest logging. Not only do crops for human consumption require fertile soil, but also ones that can be used as cow feed. For this reason, if grazing pastures are more productive, animals will have more food. RA techniques involve reclaiming land that has been left idle owing to farming activities or is no longer in use, in addition to protecting the fertility of already farmed regions. This comprises ecological aquaculture, buffer zone fortification, peat land restoration, and reforestation. A system for preserving and restoring food and farmland is called RA [16].

Regenerative organic farming's primary goal is to restore severely damaged soil, which benefits water quality, plant growth, and land output in a symbiotic manner, [9]. According to Kastner, "We could trap more than 100% of present yearly CO_2 emissions with a move to widely accessible and reasonably priced organic management approaches, which we dub "regenerative organic agriculture" [17]. Yet, other experts are dubious about the potential of RA to achieve long-term sustainability goals [18].

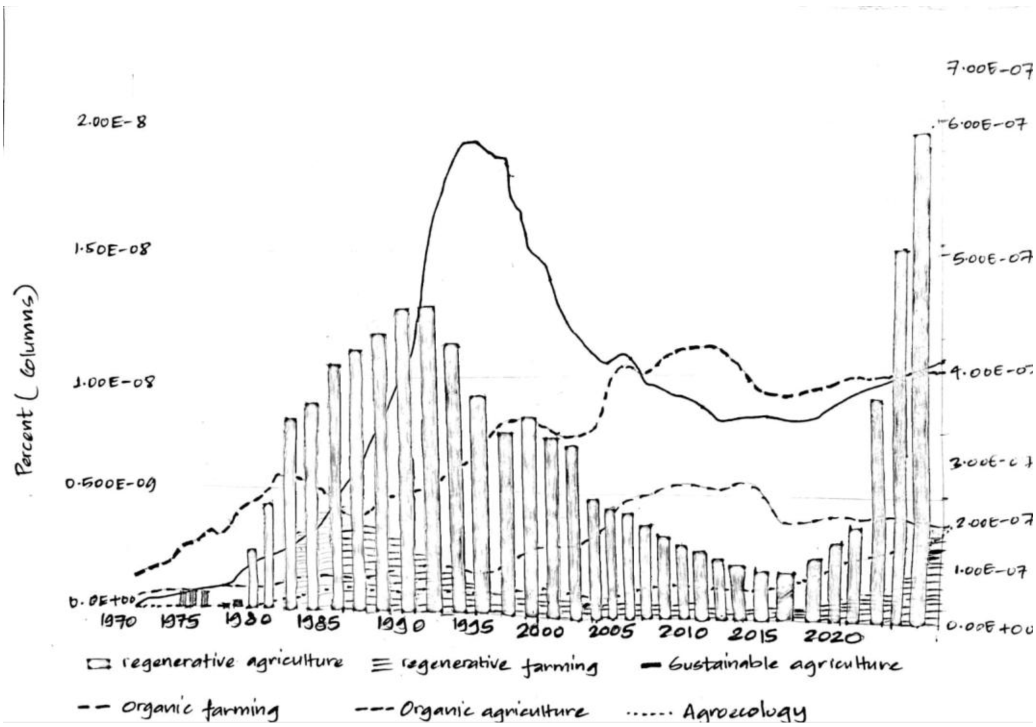

Fig. 1. The frequency of key terms in books (3-year rolling averages)
Source: Google N-Gram Viewer, Corpus 'English 2019' which includes books predominantly in the English language published in any country

2.1 About Regenerative Sustainability

The term "regenerative sustainability; RS" has been referred to as the future of sustainability [19] and an important paradigm change and perspective for sustainability. "RS considers people and the rest of life as one auto-poetic system in which the particular essence and potential of each area or community are represented through developmental change processes. The aspirational goal of RS is to bring about thriving living systems (complicated adaptive systems) in the fully integrated individual-to-global system. "Recent scientific understandings in ecology, quantum physics, systems theory, developmental change theory, psychology, neuroscience, design, planning, and sustainability support the idea that this is feasible and a goal that is rational, essential, and desirable, as well as older ways of knowing and being in the world (i.e., indigenous knowledge and practices, eastern spiritual traditions, and philosophies" [20].

Over time, various paradigms for sustainability have emerged, each of which builds upon and transcends the previous. Sustainability is mostly anthropocentric and based on a mechanical viewpoint. Justice, complex adaptive systems, and transdisciplinarity are examples of contemporary sustainability principles that advance traditional sustainability. The next phase of sustainability, known as RS, bases its goals on healthy, fully-functioning biological systems and takes a comprehensive approach to problem-solving. It combines the inner and outer spheres of sustainability and concentrates on altering deep leverage points in systems for transformative change of various sizes.

2.2 Principles of Regenerative Organic Farming towards Sustainability

There are five guiding concepts towards regenerative agriculture; (1) Field treatments including mechanical, chemical, and physical methods are no longer employed. This regenerative agriculture idea is reminiscent of pre-industrial regenerative agriculture. (2) Usage of cover crops year-round to prevent bare soils and lessen soil erosion Furthermore, this regenerative agricultural technique offers pasture and grazing material for chickens and cattle. (3) Expanding the biodiversity (e.g., with crop rotation, agroforestry, and silvi-pasture techniques). (4) Making use of cattle to assist in agricultural production. (5) Living roots are retained in perennial crops.

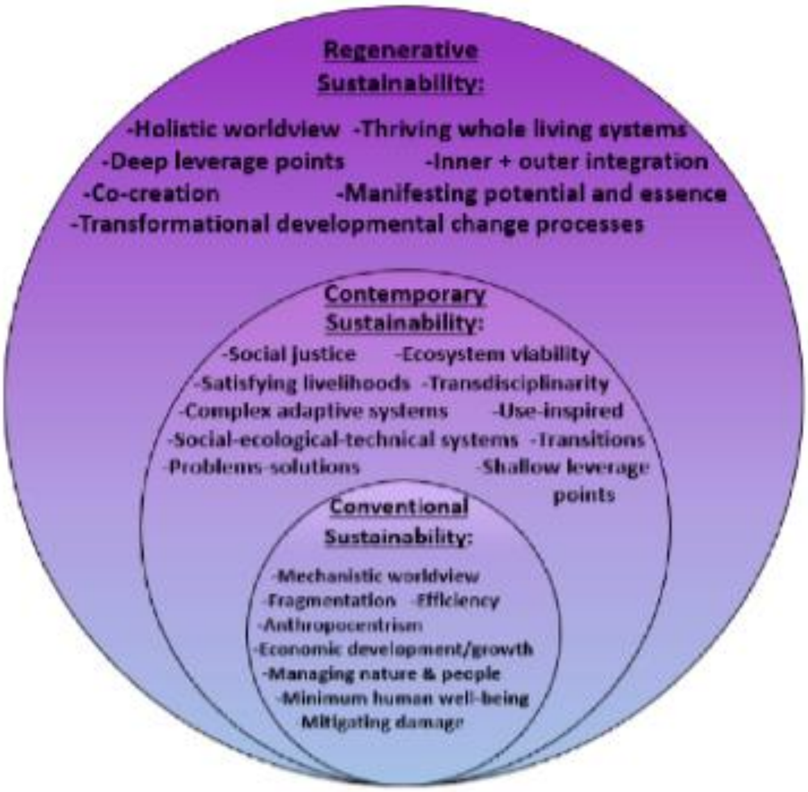

Fig. 2. Concepts for sustainability [21]

All of these concepts aim to preserve a regenerative agricultural cycle from one year to the next. But, they are not all-inclusive, and each farm's particular qualities will determine how to combine and employ them [16].

2.3 The Substitution of Regenerative Development Goals with Sustainable Development Goals

"By being more all-encompassing, increasing living systems' capacity for self-organization at all scales, combining inner and outer sustainability, and setting healthy communities as their ultimate goal, development goals can help bring about RS. This calls for the substitution of regenerative development goals (RDGs) for the Sustainable Development Goals (SDGs). The SDGs provide goals, objectives, and principles for modern sustainability, but they do not support whole, flourishing living systems. They have proven to be synergistic, leading to tradeoffs that further distance communities from sustainability" [22].

"The main goal of RDGs is to develop the traits (i.e., capacity) of regenerative biological systems. Communities must co-create and co-implement place-based indicators and strategies to direct thinking and action while adhering to general indicators and strategies for regenerative living systems and regenerative development principles, integrating ecological and sociocultural aspects of living systems, as well as process and product domains of development and design endeavors across scales of space and time. In addition, a variety of perspectives, as well as quantitative and qualitative data, are combined. The major objectives are to enhance residents' and stakeholders' capacity to make these integrations and to synergistically integrate RDGs (i.e., think holistically). Self-organization, emergence, and viability stem from these linkages" [23].

2.4 The Scale and Productivity of the Sustainable System

Since the Amish have "maintained their culture for hundreds, if not thousands of years," there is no question that some farming systems, including theirs, are sustainable at the farm level [24,25]. The problem that tends to hinder this view from being widely accepted is the level of productivity if one removes the specifics of the religious and cultural features of these communities and concentrates on the production system. This productivity issue merits considerable thought if one is thinking about the sustainability of agricultural systems. In emerging nations, where the population is increasing urbanization and disengaging from agricultural production, the challenge is to create sustainable farming systems with productivity rates high enough to maintain the current demographic trends. The only requirement for a farming system to be sustainable is that the people who depend on it can live independently. It's also important to solve the problem of feeding non-agricultural people food and Fiber. Does sustainable agriculture necessitate a large-scale return to the land and the end of much of today's industrial and manufacturing production if it necessitates small-scale, labor-intensive farming because such large urban populations could not be supported in the context of this form of agricultural production?

The solution is unclear, but it would be wrong to automatically lump sustainable agriculture together with low-yield farming. Although organic farming and traditional crop rotations may play a significant role in a sustainable future state, "We do not believe that the keys to sustainability are the technologies of the past. We cannot turn the clock back and still feed the current human population."Avery, a former agricultural expert for the US Department of State, is one of the strongest defenders of this point of view. Save the Earth with Pesticides and Plastic. The Environmental Triumph of High-Yield Farming contrasts organic farming with "high-yield farming," arguing that the latter poses a serious threat to biodiversity because, in his opinion, the lower yields it generates would result in the loss of large areas of species-rich wildlife habitats to cultivation: "the public has been told that the organic approach to farming is kinder to the environment. The general people have not been informed that its low yields will need the eradication of further millions of square miles of wildlands. [26].

3. A WAY OF SUSTAINING CLIMATE CHANGE

System-based conservation agriculture (CA), which combines no-till farming with residue mulching, cover crops, integrated nutrient and pest management, complex rotations, and blending of crops with trees and livestock, is a subset of RA [27]. The site-specific package(s) of RA must be adjusted in the context of biophysical elements and the human dimensions because it is all-inclusive. The extended concept, which is based on Balfour's 1943 realization of the living earth, is particularly relevant in the COVID-19 era [13]. The objective is to strengthen coupled biogeochemical cycling of carbon (C) with water, Nitrogen (N), Phosphorous (P), Sulphur (S), and other elements, as well as to increase soil organic matter (SOM) content [28].

3.1 Word on Conservation Agriculture and its Adaptability

“The soil-centric strategy is concentrated on achieving an optimal output sustained throughout time with little reliance on agricultural chemicals. It stands in contrast to the conventional strategy, which relies on excessive and indiscriminate use of chemical fertilizers, pesticides, tillage, and other energy-based inputs to achieve large yields over a short period. Therefore, instead of asking whether RA is effective, it would be more appropriate to ask how to make it so under site-specific conditions that take into account the biophysical, social, economic, and human components. Recent developments in system-based methods of CA adaptation have extended application, boosted worldwide adoption, and accelerated adoption” [29]. Therefore, RA aims to apply the idea of more from less to agriculture less land area, less chemical input, less water use, less emission of greenhouse gases, less risk of soil degradation, and less use of energy-based inputs. The strategy is to preserve land and resources for nature. Environmental pollution and food waste are crimes against nature.

3.2 Goal toward the Maintenance of Soil, Water, and Air Quality

For science to be put into practice, policy needs to be identified and developed. To complement the current Air and Water Quality Acts and capitalize on the benefits of the soil-water-air nexus, it is crucial to implement a "Soil Quality Act" [30]. The soil quality act aims to make agriculture a solution to environmental problems, and will also reward farmers through payments for ecosystem services like the sequestration of carbon in soil and vegetation (terrestrial biosphere), improving the quality and renewability of water resources, enhancing biodiversity, and making agriculture nutrition-sensitive.

Table 1. Potential and aims of regenerative agriculture [13]

Parameter	Expectations and outputs
Agronomic yield and productivity	Optimum and sustainable
Inputs of chemicals	Supplemental, as and when needed
Resource use	Produce more per unit of land, water, and energy
Global warming	Positive soil/ecosystem carbon budget in accord with the 4 per 1,000 initiatives, resilience to drought/ heat waves and extreme events, minimal emissions of methane (CH_4), nitrous oxide (N_2O)
Profitability	Optimal and sustained over time
Soil degradation, land desertification degradation neutrality Food Quality	Reversed, and focused on land Nutrition-sensitive agriculture
Environment quality environment Incentivization of natural resources	Making farming integral to restoring and enhancing the Payments for ecosystem services based on the societal value
Legislation	Soil Quality Act to complement the Clean Air Act and Clean Water Act

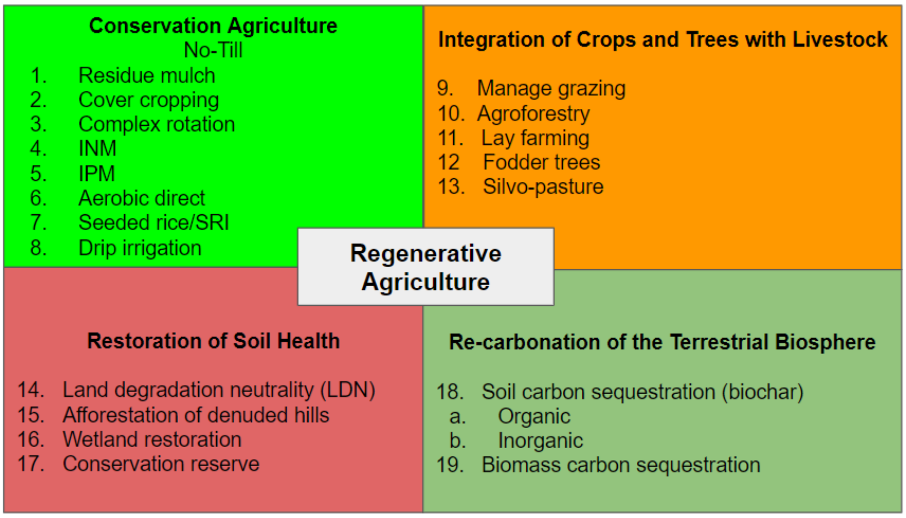

Fig. 3. Shows the basis of INM, IPM, SRI, biochar, etc

In narratives about RA, soil health is given significant emphasis [31, 10]. Most, if not all, demands for RA are based on the notion that soil, and soil life in particular, are under threat. But, the phrase "soil health" is by its very nature problematic [32]. Similar to soil quality, soil health is a container notion that needs to be broken down to be meaningful. Although it can be seen as a goal worth pursuing, the underlying soil functions require significant indicators that can be measured and watched over an extended length of time. Furthermore, [6] found that "there are frequently many trade-offs in soil health and that agronomic techniques that benefit one element of soil health, like soil life, frequently have negative consequences on other functions".

3.3 SOM and GHG Emissions

"In low-yielding areas, where growing crop yields increase the amount of biomass stock available and the amount of organic matter added to the soil, there are the greatest chances to boost soil carbon" [34]. The annual rate of increase in soil C is only transient, even if SOM rises as a result of better management. The rate of carbon accumulation slows as a new equilibrium is reached [35], and a new equilibrium is reached under cultivation at a lower level than under a natural vegetative cover. Soil C stores must be protected by limiting the conversion of forest and natural grasslands to agriculture. Agroforestry, in all of its varied forms, may have the greatest potential to aid in the mitigation of climate change due to its ability to trap carbon dioxide both above and below ground [36,37]. Crop yields are mostly benefited from increasing SOM because of the nutrients, particularly N, that it offers, according to a synthesis of 14 meta-analyses conducted globally [38]. Yet, to maintain production over the long run, external supplies of additional nutrients are needed to make up for the nutrients lost through harvested crops due to symbiotic nitrogen fixation through legumes. Most intergovernmental panel on climate change (Intergovernmental Panel on Climate Change) scenarios incorporate net-negative emission technologies to keep global warming to a maximum of 1.5°C, over pre-industrial levels given present trends in greenhouse gas emissions [38]. “These technologies involve soil C sequestration and reforestation in addition to carbon capture and storage” [38]. This suggests that RA may hold the key to "zero carbon farming" or even the offset of greenhouse gas emissions from other industries [39]. The Rodale Institute's most recent publication "confidently states that global adoption of regenerative methods throughout both grasslands and arable areas could capture more than 100% of current anthropogenic CO_2 emissions" [40].

3.4 Integrated Pest Management (IPM)

IPM encompasses suggested techniques like rotations and (multi-species) cover crops, as well as strategies like intercropping and strip farming that is often disregarded in talks on regenerative agriculture. IPM needs a high level of knowledge, regular crop monitoring, and the ability to spot early indications of outbreaks of several pests and diseases. The perceived risk of crop loss is one of many complex reasons why IPM systems have not been adopted [2]. Integrated weed management (IWM) is marketed as an eco-friendly strategy that can use diversity to control the negative effects of weeds [1], but it is also a highly knowledge-intensive technique.

4. WAYS TO COMBAT GLOBAL WARMING

4.1 Vermicomposting for Sustainable Agriculture

Vermicomposting is a chemical and biological process that uses earthworms and microorganisms to recycle nutrients. Therefore, vermicompost is regarded as a nutrient-rich organic fertilizer containing diverse microbial communities [41,42]. The vermicomposting technique is well-known and widely used around the world and is considered to be a common technique. As a method of dealing with organic residues, it represents an alternative approach to waste management, neither landfilled nor incinerated, but considered a recyclable resource. It is a sustainable, low-cost, eco-friendly technology that efficiently treats biodegradable waste and recycles hazardous and valueless organic waste into safe and valuable products [42].

4.2 Vermicomposting in Mitigating and Combatting Global Warming

Earthworm farming technology facilitated by several versatile, chemically tolerant, waste-feeding species of earthworms that Sir Charles Darwin called "mankind's unprecedented soldier" and "the farmer's friend" promises a soft and sustainable alternative to some of the Construction Methods of development and waste management while protecting the environment. Vermicompost technology diverts waste from landfills and turns it into nutritious vermicompost for on-farm use. Vermifiltration technology purifies wastewater and makes it suitable for agricultural irrigation. Insect remediation technology treats contaminated soil on-site without excavating the soil clears the soil for development purposes, and makes it fertile for agriculture. Vermicompost has been proven to be a "miracle plant growth enhancer". It promotes 30-40% over chemical and organic fertilizers and protects plants from pests and diseases. They can be a sustainable alternative to 'destructive pesticides' that act as 'slow food poisoning' for humanity. It also “sequesters” vast amounts of atmospheric carbon (CO_2) and buries it in the soil as “soil organic carbon” (SOC), mitigating global warming [43,44].

“Landfills have proven to be an economic and environmental burden for society. Waste management with vermicompost can divert large amounts of waste from landfills. Landfills emit huge and more powerful greenhouse gases methane (CH) and nitrogen oxides (N_2O). They are 22 times more potent than CO_2 per molecule. For every kg of waste diverted from a landfill, kg of greenhouse gas emissions equivalent to CO_2 are avoided. In 2005, landfill disposal of MSW contributed 17 million tonnes of CO_2-e (equivalent) to its GHG in Australia” [45].

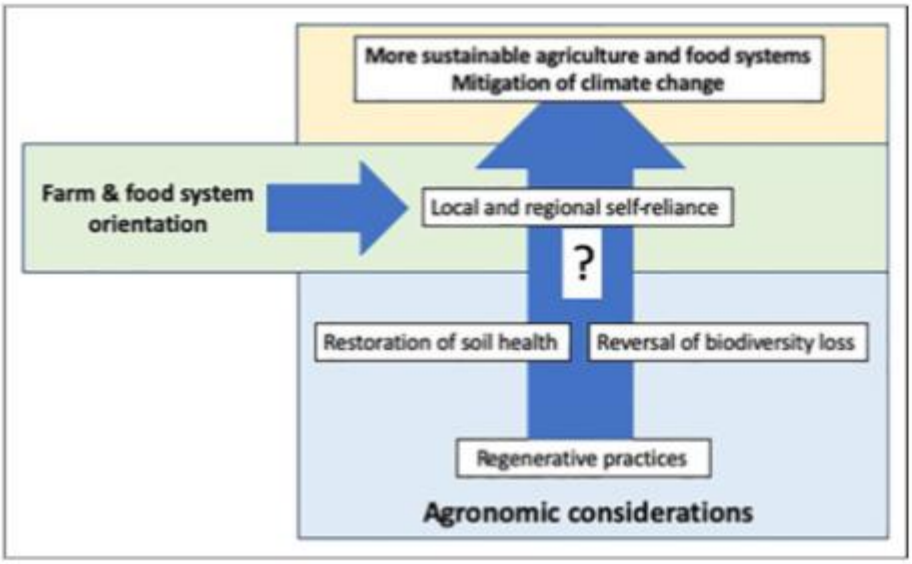

Fig. 4. Regenerative Agriculture: Authors' interpretation of the commonly used theory of change in 2021. Our analysis focuses on the lower blue box: 'agronomic considerations' [33]

Studies have shown that "composting earthworm waste significantly reduces total greenhouse gas emissions, especially nitrous oxide (N_2O), which is 296-310 times more powerful CHG than CO_2. The study showed that the vermicomposting system emitted an average of 463 CO_2-e/m^2/h. This is significantly less than the landfill emissions of 3640 CO_2-e/m^2/h. Vermicompost released at least N_2O – 1.17 mg/m^2/h compared to aerobic and anaerobic compost (1.48 and 1.59 mg/m^2/h, respectively). Therefore, earthworms can play a good role in greenhouse gas reduction and mitigation strategies in municipal solid waste disposal" [43, 46].

4.3 Soil Solution Solving Global Warming

Regenerative organic farming can transform agriculture from part of the global warming problem to a large part of the solution by changing the way we farm. Farmers can switch to new practices relatively quickly and cheaply using inexpensive tools. Carbon dioxide levels are minimal in the summer when lush vegetation promotes a sponge effect, and peak in the winter, when plants are dormant. However, the greenhouse gas spongy nature of the soil itself can make a bigger difference than what grows on land. On a global scale, soil contains more than twice as much carbon (estimated 1.7 trillion US tons) as terrestrial vegetation (672 billion tons). Data from the Rodale Institute and other studies show that regenerative, organic practices reduce farmland carbon by creating a 'humic' soil material (a.k.a. soil organic matter) that persists as a stable carbon compound for many years. It shows that storage can be changed dramatically. Organically managed soils can convert carbon from greenhouse gases into food-producing assets. Soils rich in carbon conserve water and support healthy plants that are more resistant to drought stress, pests, and diseases. Our research on organic systems shows a nearly 30% increase in soil carbon over 27 years. Petroleum-based systems showed no significant increase in soil carbon over the same period, and some studies indicate that these systems may lose carbon.

Researchers have embodied the mechanism by which this soil carbon sequestration occurs. One of the most important findings is the high correlation between elevated soil carbon levels and very high mycorrhizal fungal levels. These fungi help slow down the decomposition of organic matter. Starting with the Farming Systems Trial, in collaboration with his USDA Agricultural Research Service (ARS) led by Dr. David Douds, his biological support system of mycorrhizae was organically grown, it shows more breadth and versatility than soil that relies on artificial fertilizers and pesticides.

"These fungi act to preserve organic matter by aggregating it with clays and minerals. In soil aggregates, carbon is more resistant to degradation than in the free form and thus more likely to be conserved. These results indicated that mycorrhizal fungi produce a potent glue-like substance called -glomalin that stimulates increased cohesion of soil particles. This increases the carbon storage capacity of the soil. These results are based on ARS researchers at the Northern Great Plains Research Lab in Mandan, North Dakota" [47].

5. CARBON FOOTPRINT OF ORGANIC FARMING

"Awareness of climate change and global warming has led to a large body of research comparing greenhouse gas (GHG) emissions from different agricultural production systems in Europe. Organic farming is an environmentally friendly system and is in line with sustainable agricultural development" [48,49]. "However, the literature and studies using Life Cycle Assessment (LCA) methodologies in crop production in organic and conventional systems have different opinions on the environmental aspects of crop production in these two systems. Conventional production methods can achieve high yields by using large amounts of pesticides and agricultural machinery. Organic farming is typically characterized by the use of fewer inputs and lower yields. The environmental impact of organic farming per unit area is usually lower than conventional production. The environmental impact of organic farming is likely to be greater on product units" [50,51,52].

6. CARBON SEQUESTRATION

"The potential for organic carbon (C) sequestration throughout the Farm area is often overlooked. It should be emphasized that proper management of soil organic matter (SOM) in an agricultural production system is an important factor in reducing the greenhouse effect. The decomposition of SOM increases greenhouse gases. To prevent SOM decomposition and the loss of C, it is necessary to maintain a constant flow of organic matter to the soil in the form of crop residues, root pulp, and natural fertilizers" [53,42]. "Leaving large post-harvest residues on the soil surface protects cultivation, promotes the accumulation of organic C, reduces fuel consumption, reduces the risk of water and wind erosion, and increases soil stability, soil aggregates, water retention, higher soil water capacity, and preservation of biological diversity in underground soil layers. Conservation cropping with straw mulch is a drought-tolerant practice. When mulch is used, the soil remains covered, and the amount of organic matter in the soil increases. Although all types of cover crops have many benefits, some types are better, depending on specific goals, such as preventing erosion or improving soil quality. Therefore, growing a mix of cover crops such as grasses and legumes serves several purposes at once" [54]. "The cultivation of deep-rooted plants such as perennial legumes and grasses is essential for the accumulation of soil organic matter" C [55]. "Deep mixing of the soil with crop residue is advantageous. Limiting C loss by slowing the rate of mineralization of organic matter is a factor in protecting that soil resource. SOM growth may stop after 20–30 years due to agricultural practices that increase organic matter content" [56,57]. After this period, the organic matter content stabilizes and shows no tendency to accumulate further in the soil.

7. CONCLUSION

Regenerative agriculture and sustainability go hand-in-hand. Regenerative Sustainability is all about inner and outer integrations, co-existence, manifesting potential, and essence, transformational developmental change processes, etc. Contemporary Sustainability comprises social justice, ecosystem viability, social-ecological technical system, etc. Conventional Sustainability comprises a mechanistic worldview, fragmentation, anthropocentrism, managing nature, and people, etc. For regenerative living systems and regenerative development principles, Regenerative Development Goals (RDGs) have been replaced by Sustainable Development Goals (SDGs). As for sustaining climate change, system-based Conservation Agriculture (CA), and Integrated Farming are utilized in which no-till farming, cover crops, and IPM are used along with soil organic matter (SOM). Regenerative agriculture has helped in the re-carbonation of the terrestrial biosphere, integrating crops with livestock, restoring soil health, and conservation agriculture.

As for depleting climate features, the soil, water, and air qualities should be kept an eye on. The primary aim of RA is to apply the idea of more from less to agriculture; less land, less chemical, less water use, less GHG emissions, etc. The more the quantity of SOM in the soil, the better the soil quality. Soil Carbon reserves should be protected by reducing the conversion of forests and natural grasslands into agricultural lands. To protect Soil C, sequestration and reforestation in addition to carbon capture and storage. This suggests that regenerative agriculture may hold the key to "zero carbon farming" or even the offset of GHG emissions from other industries. Regenerative agriculture has contributed to the fields of IPM and IWM.

Global Warming is a rising issue that needs to be protected from spreading further. The methods such as vermicomposting help in maintaining sustainability in nature and maintains and improve soil quality and health. Vermifiltration filters the water before irrigating the agricultural fields. Organically managed soils can convert carbon from greenhouse gases into food-producing assets. Soils rich in carbon conserve water and support healthy plants that are more resistant to drought stress, pests, and diseases. There is a profound relationship that has been found between elevated soil carbon levels and very high mycorrhizal fungal levels. These fungi help slow down the decomposition of organic matter. The Carbon Footprint and Carbon Sequestration go hand-in-hand as they contribute to sustainability in RA.

COMPETING INTERESTS

Authors have declared that no competing interests exist.

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