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RECENT INNOVATIVE APPROACHES IN AGRICULTURAL SCIENCE VOLUME II



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BHUMI PUBLISHING

**Recent Innovative Approaches in
Agricultural Science
Volume II**

ISBN: 978-93-91768-85-0

Editors

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Bhumi Publishing

2022

REGENERATIVE AGRICULTURE: INTRODUCTION AND PRACTICES FOR SUSTAINABLE PRODUCTION

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Abstract:

Agriculture associated with one third of global land use and it has a significant importance in land use change globally. Agriculture has been sitting at the heart of some of the world's most pressing challenges for year's *i.e.*, food security and nutrition, water and soil quality, biodiversity, and sustainable livelihoods. It is in crisis due to claims of ill health, hunger, poverty, obesity, through industrial farming, poor quality food, environmental degradation and biodiversity loss, and excess use of chemical fertilizers and lack of resilience. Most recently, COVID-19 has continued to expose the inequalities and weaknesses within existing global supply chains, the vulnerabilities of farmers, and the growing numbers of people unable to afford or access healthy food. Global food system releases of about 25 per cent greenhouse gases emission which causes about one third of terrestrial acidification, responsible for major global eutrophication of surface water. If agriculture system continues with modern practices such as using synthetic pesticides, artificial fertilizers, fossil fuels and excess food waste, the carrying capacity of the planet likely to be suppressed.

Key words: Agriculture, food, soil and practices.

Introduction:

Regenerative agriculture is a farming idea that aims to rehabilitate soil and maintain it productive for as long as possible in order to avoid expanding to new places at the expense of forest logging, for example. Soil fertility is needed not just to grow crops for human use, but also to supply feed for cattle. This is why animals will have more food if grazing fields are more productive. Fertile soil is necessary not only for human happiness, but also for human existence. This is why regenerative agriculture, along with other resource-conserving agricultural methods (no-tilling, soil conservation, and organic farming), becomes a critical issue. Long-term, soil deterioration promotes food shortages by dramatically lowering nutritional value, biodiversity, and planting areas. Regenerative agriculture is good for the soil, rejuvenating and sustaining its fertility for future generations. Regenerative agricultural approaches attempt to reduce the negative effects of farming, such as erosion, depletion, insect invasions, desertification, salinization, decarbonization, chemical pollution, and so on. Regenerative agriculture is a broad term that encompasses a variety of practises. Regenerative

agriculture advocates, on the other hand, employ a range of sustainable agriculture approaches in tandem. Recycling as much agricultural trash as feasible is one of the practices, as is adding composted material from outside the farm. Permaculture, agro ecology, agroforestry, restoration ecology, Keyline design, and holistic management are all common principles used in regenerative agriculture on small farms and gardens. Large farms are less concerned with philosophy and frequently employ "no-till" and/or "reduced till" methods. Because soils are more tolerant to adverse weather and house fewer pests and diseases, input needs may reduce and crop yields may increase as soil health improves. The majority of climate change mitigation initiatives focus on "cutting greenhouse gas emissions." Regenerative agriculture, or the capture of atmospheric carbon dioxide by growing plants that move that carbon dioxide into the soil, is nearly the only currently-working technology for drawing down greenhouse gases already in the atmosphere, primarily through the cultivation and nurturing of forests and permanent perennial pastures and grasslands.

Agriculture is facing major issues across the world, as governments, companies, research agronomists, farmers, and consumers try to strike a delicate yet dynamic balance between human welfare (or the "right to food"), production, profitability, and environmental sustainability. However, because agroecosystems, farm systems, and policy settings are so diverse, the nature of these difficulties can change substantially across time and geography. This reality calls into question any claim that a single, universally applicable issue description or particular agronomic solutions can be identified to relieve strains on the global food system. As a result, regenerative agriculture might play a role in mitigating climate change. The governmental, business, and non-profit sectors are all interested in regenerative agriculture. Governments at all levels, from world to local, are investigating the potential for regenerative agriculture to contribute to climate change initiatives.

Origin (history) of regenerative agriculture

- The adjective 'regenerative' has been connected with the nouns 'agricultural' and 'farming' since the late 1970s (Gabel, 1979), but the words Regenerative Agriculture and Regenerative Farming were more well known in the early 1980s after being adopted by the Rodale Institute in the United States. The Rodale Institute has been at the forefront of the organic agricultural movement for decades through its research and publications (particularly the periodical *Organic Gardening and Farming*).
- Regenerative agriculture, according to Robert Rodale (1983), is "one that, as productivity rises, expands our land and soil biological production base." It has a high level of economic and biological stability built into it. Beyond the farm or field limits, it has little to no influence on the ecosystem. It creates meals that are devoid of biocides.
- Richard Harwood, an agronomic who earned a name for himself in the worldwide agricultural systems research movement (Escobar *et al.*, 2000), was Director of Rodale Research Centre when he released an "international overview" of Regenerative Agriculture (Escobar *et al.*, 2000). (Harwood, 1983). The review goes to great lengths to place Regenerative Agriculture in the context of the historical evolution of various schools of organic and biodynamic farming, but it also highlights Rodale's claim that Regenerative Agriculture was more than organic because it

included changes in "macro structure" and "social relevancy," as well as a goal of increasing rather than decreasing productive resources (Rodale, 1983).

- Francis *et al.* (1986) connects it to organic farming and 'low external input agriculture,' emphasizing the necessity of biological structure, progressive biological sequencing, and integrated farm structuring. They also link it to nitrogen fixation, nutrient cycling, integrated nutrient management, crop rotation, integrated pest management (IPM), and 'weed cycling,' among other' specific technologies and systems.'

Points summarizing the regenerative agriculture philosophy as presented by harwood (1983: 31).

1. Agriculture should create high-yields of extremely nutritious food that is free of biocides.
2. By improving the depth, fertility, and physical properties of the higher soil layers, agriculture should increase rather than diminish soil production.
3. Nutrient-flow systems that completely integrate soil flora and fauna into the pattern are more efficient and environmentally friendly, as well as providing greater crop nutrition. Such systems provide a fresh upward flow of nutrients in the soil profile, which reduces or eliminates negative environmental effects. By definition, such a process is a soil genesis process.
4. To ensure crop stability, crop production should be based on biological interactions, rather than manufactured biocides.

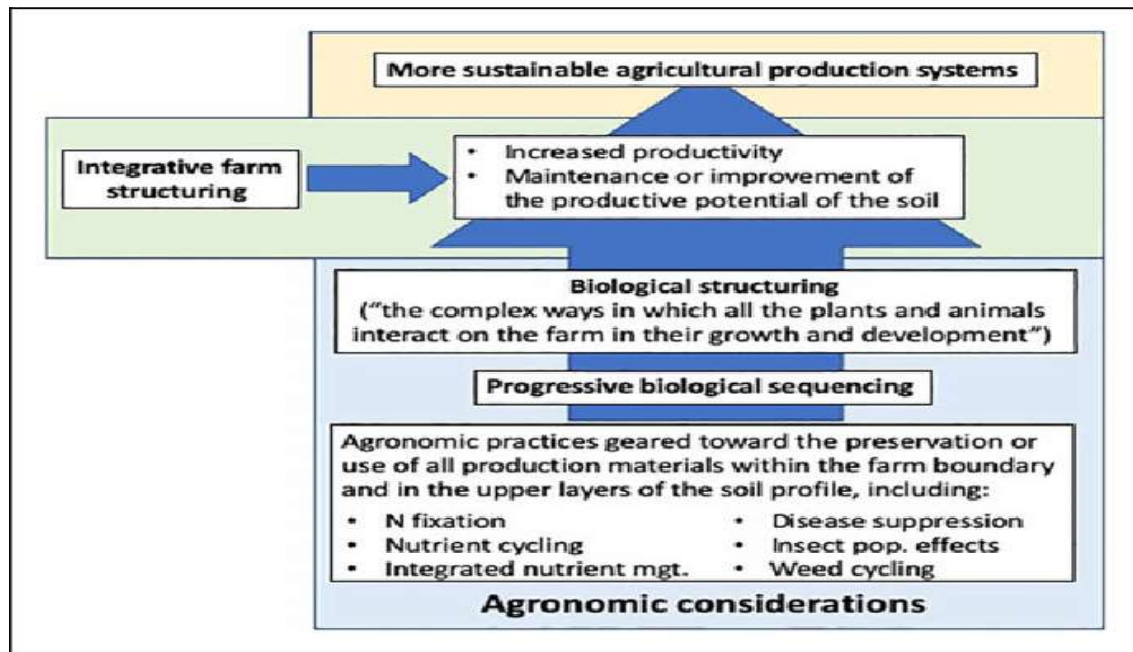


Fig. 1. Depicts the Regenerative Agriculture theory of change as articulated by Francis *et al.* (1986)

5. Substances that damage the agricultural system's biological structure (such as today's synthetic fertilizers) should not be employed.
6. In order to function biologically, regenerative agriculture need a close interaction between the system's management and participants, as well as the system itself.

7. Integrated systems that are essentially nitrogen self-sufficient due to biological nitrogen fixation should be used.
8. Agriculture animals should be fed and kept in such a way that hormone and antibiotics are not utilized prophylactically, resulting in antibiotics in human food.
9. Agricultural production should result in increasing employment levels.
10. To stop nutrient-flow loops, regenerative agriculture needs national-level planning as well as a high level of local and regional self-reliance.

Recent developments (since 2010)

- ❖ While the term has existed for decades, regenerative agriculture has increasingly showed up in academic research since the early to mid-2010s in the fields of environmental science, plant science, and ecology.
- ❖ In 2013, Allan Savory presented a TED lecture about combating and reversing climate change. He also founded The Savory Institute, which teaches ranchers how to manage their property holistically. Land Stream was founded by Abe Collins to track ecosystem performance on regenerative agriculture fields.
- ❖ In 2016, Eric Toensmeier released a book on the issue.
- ❖ In 2019, General Mills launched an attempt to promote regenerative agriculture methods in their supply chain, and hired the non-profit Kiss the Ground to provide regenerative agriculture teaching programmers in agricultural areas that support the company.
- ❖ However, academic and government experiments on farming sustainability have criticized the initiative. Gun smoke Farm, in particular, collaborated with General Mills to convert to regenerative agricultural techniques and serve as a learning center for others. Local experts are concerned that the farm is now causing more damage than good, with agronomic Ruth Beck claiming, "Environmental marketing got ahead of what farmers can actually achieve."
- ❖ PepsiCo said in 2021 that by 2030, they will engage with their supplier chain farmers to create regenerative agricultural methods throughout their 7 million acres.
- ❖ In 2021, Unilever announced a comprehensive plan to integrate regenerative agriculture across their whole supply chain.
- ❖ The North Face, Timberland, and Vans' parent company, VF Corporation, announced collaboration with Terra Genesis International in 2021 to build a supply chain for their rubber that originates from regenerative agricultural sources.
- ❖ Nestle announced a \$1.8 billion investment in regenerative agriculture in 2021, with the goal of reducing emissions by 95%.

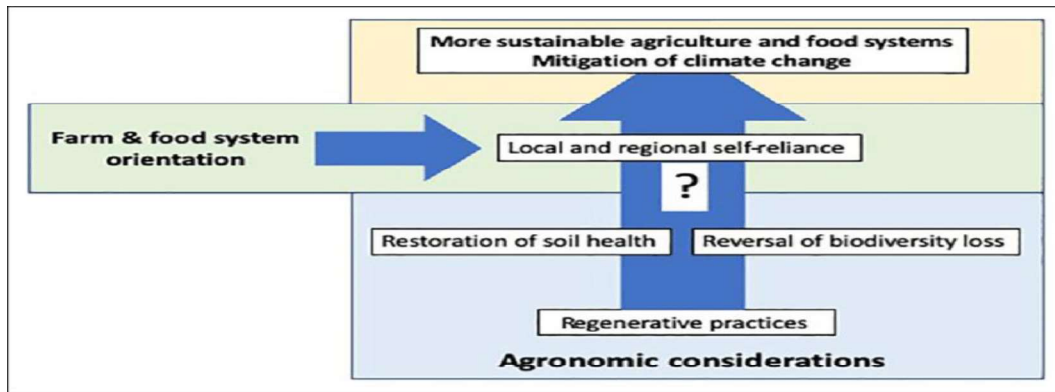


Fig. 2. In 2021, regenerative agriculture will be interpreted using the most widely utilized theory of change

What is regenerative agriculture?

Regenerative agriculture is a farming idea that aims to rehabilitate soil and maintain it productive for as long as possible in order to avoid expanding to new places at the expense of forest logging, for example. Soil fertility is needed not just to grow crops for human use, but also to supply feed for cattle. This is why animals will have more food if grazing fields are more productive. Aside from preserving the fertility of already farmed regions, regenerative agriculture strategies include reclaiming land that has been abandoned due to farming operations or is no longer in use. This includes, for example, reforestation, peat land restoration, buffer zone fortification, ecological aquaculture, and so on.

Regenerative agriculture is a food and agricultural system conservation and restoration method. It focuses on boosting topsoil regeneration, increasing biodiversity, improving the water cycle, expanding ecosystem services, supporting bio sequestration, increasing climate change resistance, and strengthening agricultural soil health and vitality.

- "At its heart, regenerative agriculture aims to improve the health of soil or recover badly damaged soil, which symbiotically improves the quality of water, plants, and land production," according to Rhodes (2017). "Regenerative agriculture enhances and sustains the health of the soil by restoring its carbon content, which in turn improves productivity—exactly the opposite of conventional agriculture," according to Project Drawdown, which estimates that regenerative annual cropping could reduce or sequester 14.5–22 gigatons of CO₂ by 2050. (Project Drawdown, 2020).
- "Regenerative agriculture... has the potential to reverse climate change," according to Kastner (2016), and "we could sequester more than 100% of current annual CO₂ emissions with a switch to widely available and inexpensive organic management practices, which we term "regenerative organic agriculture" (Rodale Institute, 2014). At the same time, other pundits are skeptical about regenerative agriculture's capacity to contribute to long-term sustainability goals (McGuire, 2018; Ranganathan *et al.*, 2020).

Internationally, the Intergovernmental Panel on Climate Change's Special Report on "Climate Change and Land" identified regenerative agriculture as a "sustainable land management technique"

focusing on ecological services that "may be successful in developing agro-ecosystem resilience" (IPCC, 2019, page 389).

Principles of regenerative agriculture

Environmental sustainability and human health are at the forefront of regenerative agriculture. It means that, in addition to generating marketable crops, each farm should contribute to environmental conservation. The key benefits include increased biodiversity, enhanced soil characteristics, and improved environmental conditions.

Five principles of regenerative agriculture

A farmer practicing regenerative agriculture recognizes five main principles defined by Gabe Brown that imply the following:

1. Mechanical, chemical, and physical field treatment are no longer used. This pre-industrial regenerative agricultural notion is echoed in this regenerative agriculture principle.
2. Use of all-year-round cover crops to reduce erosion by avoiding bare soils. In addition, pasture and grazing material for poultry and cattle are provided by this regenerative farming system.
3. Increasing biodiversity (e.g., with crop rotation, agroforestry and silvi-pasture techniques).
4. Using livestock to help in agricultural production.
5. Perennial crops' living roots are preserved.

All of these ideas strive to maintain a regenerative agricultural cycle from season to season and year to year. However, they are not universal, and their combinations and uses are dependent on the unique characteristics of each farm.

Practices in regenerative agriculture

Regenerative farming encompasses more than just preserving and recovering forests, adding organic matter, and increasing soil fertility. Regenerative agriculture has a number of environmental benefits, including carbon sequestration to remove emissions to the atmosphere, reduced water and soil pollution due to lower chemical inputs, and increased biodiversity. We can breathe cleaner air and reduce the greenhouse effect by preserving more trees and storing carbon in the soil. Furthermore, preserving biodiversity necessitates the preservation of natural environments.

The list of regenerative agriculture practices is quite extensive:

(1) No-Till and Pasture Cropping

No-till farming causes the least amount of soil disturbance, which decreases soil erosion and CO₂ emissions. Seeding is done using specialist drillers or disc planters in this situation. When grains are utilised as grazing grasses, pasture cropping is an important aspect of regenerative agriculture. It also aids farmers in avoiding bare soils and thereby preventing erosion.



Newly planted soybean plants are emerging from the residue left behind from a prior wheat harvest. This demonstrates no-till planting

(2) Annual organic cropping

To reduce the harmful influence on environment and humanity, organic annual cropping recommends the use of non-chemical fertilisers and pesticides. In comparison to stronger industrial processes, this regenerative agricultural system is more costly, less lucrative, and labour-intensive. However, agro-related firms will gain greatly in the long run from regenerative agriculture initiatives due to a healthier people and environment.

(3) Compost and compost tea

Compost is a vital component of regenerative agriculture because it supplies organic matter and improves soil fertility. Organic matter concentrations in the top earth layers should range from 3 to 5% and should be integrated into the soil profile for at least six inches. Compost tea is a brewed drink that contains microorganisms and soluble elements that are essential for plant growth.

(4) Bio char and terra preta

Bio char is a healthier alternative to natural charcoal that is created by burning forestry and agricultural waste. The phrase "terra preta" is a Spanish name for anthropogenic dark Indian soils in the Amazon basin with significant charcoal concentration. The amount of organic matter and nutrients in the ground is conditioned by black carbon, which is generally resistant to chemical and microbiological influences. This explains its capacity to sustain fertility for an extended period of time, which is of particular importance to regenerative agriculture practitioners. In fact, studies suggest that the black carbon concentration of terra preta exceeds that of the region's barren adjacent soils by seventy times.

(5) Holistically managed grazing

As a regenerative agricultural method, holistically planned grazing advises using pastures in a rotating pattern akin to animals' natural behaviour. Cattle consume new grass and integrate green and animal excrement as they move from area to area, increasing pastureland fertility and allowing grass on different terrains to re-grow.

(6) Animal integration into crop production

This combination improves soil fertility, aids in weed and pest management by introducing biological enemies to undesired species, and is helpful to cattle since regenerative agriculture is more similar to natural circumstances than indoor breeding.

(7) Ecological aquaculture

Planting riparian buffer strips to reduce sedimentation, water run-offs, and provide shade and extra food for aquatic dwellers is encouraged by the eco-friendly regenerative agriculture approach to fisheries and aquaculture. It calls for a decrease in chemical agricultural inputs that damage water bodies as a result of farmland leakage.

(8) Perennial cropping

In regenerative farming, perennial crops protect the land from wind and water erosion by covering it and holding it in place with their deep roots, store moisture, and minimise agricultural expenses by reducing tilling operations and weed control treatments.

(9) Silvopasture

This regenerative agriculture practise brings trees to pastures or grasses to woods with the goal of providing an additional benefit: trees on grazing areas give shade and windbreaks for animals on hot sunny days. Furthermore, its leaves provide organic matter and serves as an alternate source of nourishment for cattle.

(10) Agroforestry

The regenerative agriculture method combines agricultural crops with trees or bushes, which prevent soil erosion with vigorous root systems and shield cash species from winds and heavy rainstorms with abundant canopies.

(11) EOS crop monitoring

Fields analytics tool using high-resolution satellite pictures for locating remote issue locations. EOS Crop Monitoring aids in the maintenance of a healthy state of fields, including crops and soil, which is critical in regenerative agricultural approaches. EOS Crop Monitoring includes a range of vegetation indicators NDVI, MSAVI and NDRE to identify regions with poor vegetation or delayed plant development. Each of these indices is more beneficial at different stages of crop growth, and a low index value might indicate the presence of crop diseases and pests such as insects, harmful bacteria, fungus and other organisms. Furthermore, excessive irrigation or a lack of needed water levels has a negative impact on plant growth.

Weeds can be detected by high values of a vegetation index that coincides with a certain stage of plant growth (available on EOS Crop Monitoring).

Farmers may monitor vegetation covering throughout the season using satellite data-based vegetation index maps of a field and maintaining all-year-round land cover is one of the most common regenerative agriculture chores. Vegetation maps on EOS Crop Monitoring can show the status of the farmland: regions with dense vegetation, areas with poor vegetation, and places with no vegetation or cover (bare soils). When bare soils are discovered, regenerative agriculture requires immediate action to prevent erosion and enhance water-holding capacity.

EOS Crop Monitoring not only aids in the optimization of field treatment activities and processes in regenerative farming, but it also aids in the optimization of field treatment tasks and processes in general. It also aids in reducing the harmful effects of agricultural operations on soil and the environment in general. It has the potential to be a valuable tool for farmers who are devoted to regenerative concepts in their field operations."

Why is regenerative farming worth implementing?

One of the most difficult aspects of regenerative agriculture is the lower profit margins compared to conventional agriculture. Nonetheless, for the sake of a long-term future, farmers

throughout the world are adopting the method. The following are the primary motivations for regenerative agriculture.

1. Contribute to global food security. Small agricultural businesses provide food to people all around the world. Only 12% of worldwide agricultural areas are controlled by farms of smaller than 1 ha to 2 ha, which account for 84 percent of all farms. At the same time, large-scale farms account for only 1% of all farms yet control 65% of cropland.
2. Reduce greenhouse gas emissions. Greenhouse gases are one of the primary causes of global warming, and industrial food production now accounts for around 26% of these emissions. The problem is addressed through regenerative agriculture.
3. Fight against global warming. Although reducing GHG emissions alone will not enough to combat climate change, it can be used in conjunction with soil carbon sequestration obtained through regenerative farm management.
4. Increase yields. Organic farming is greatly encouraged by regenerative agriculture. Organic farms are less susceptible to weather extremes and produce more crops in poor weather than regular agricultural operations.
5. Deal with droughts. Organic matter helps to retain and infiltrate water by accumulating moisture in the soil. One of the most important regenerative agricultural approaches is to construct it.
6. Assist local economies Local farming is promoted in regenerative agriculture and contributes to the development of local economies.
7. Re-establish grasslands. Due to deterioration, 70% of grasslands are today unusable. A holistically managed grazing system, which is an effective regenerative agriculture technology, can help to improve the situation.
8. Research the notion of indigenous farming. Farmers who are equipped with traditional knowledge can address pertinent regenerative agriculture concerns.
9. Contribute to the preservation of biodiversity. Versatile species are advantageous not only to the farming industry, but also to environmental sustainability, which is crucial in regenerative agriculture.
10. Increase the nutritional value of the product. The variety of produced crops promotes a more well-balanced diet.

Conclusion:

Maintaining soil vitality is the top concern for any agricultural operation, regardless of size, and it looks to be a very difficult chore nowadays, as well as a key goal of regenerative agriculture. Climate change has had a significant influence on farming recently, and regenerative approaches are struggling to reverse the trend. Floods and droughts, high temperatures and severe frosts, wildfires, tornadoes, storms, and hurricanes can cause significant losses to farmers. Natural disasters pose a severe danger to food production and agriculture, necessitating the development of adaptive measures. Furthermore, extreme droughts result in significant evaporation, which, in turn, results in abnormally high rainfall or even more severe droughts. When compared to historical meteorological data, climatic patterns alter, and while precipitation is just lower than normal in some locations, it is extremely high

in others, resulting in floods. Droughts and water logging are too much for plants to handle, and they perish. Because soils cannot absorb large volumes of water in a short period of time, heavy downpours have other negative repercussions such as erosion and water contamination. Droughts are combated by organic matter, which is known for its water-retention capability and ability to enhance soil fertility. Carbon sequestration is aided by no-till farming.

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