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2. Role of Organic and Natural Farming on Environment Conservation and Soil Health

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Abstract:

The challenges in modern agriculture, including persistent hunger and malnutrition despite significant increases in production due to the Green Revolution. There are several negative impacts of chemical-based agriculture on soil health, environmental health and human health, particularly in countries like India with a large agricultural population. To address these issues, many are turning to alternative farming methods, such as organic and natural farming. Organic farming, rooted in traditional practices, aims to preserve soil health and produce food sustainably. It eliminates synthetic inputs like pesticides and fertilizers, promoting healthier soil and reducing environmental impact. Key practices include crop rotation, intercropping, cover cropping, biofertilizers, and livestock integration. These methods enhance soil fertility, control pests and diseases, and promote biodiversity. Natural farming, exemplified by Zero Budget Natural Farming (ZBNF), goes even further by minimizing external inputs altogether. It relies on indigenous methods like Jeevamrith and Beejamruth to nurture soil health and control pests naturally. Natural farming emphasizes working in harmony with nature, reducing labor and cost while enhancing soil fertility and crop yields. Both organic and natural farming offer benefits such as enhancing soil health, conserving the environment and healthier produce. However, they also have limitations and may not always match the productivity of conventional methods. Understanding these strengths and weaknesses is crucial for effective implementation. Overall, these alternative farming practices provide promising solutions to the challenges facing modern agriculture, particularly in densely populated areas like India.

Keywords:

Organic farming, Natural farming, Soil health, Sustainability, Zero Budget Natural Farming

2.1 Introduction:

In many parts of the world, persistent and widespread hunger and malnutrition continue to pose serious challenges, even in light of the notable increase in agricultural production between 1960 and 2015, which can be partially attributed to productivity-enhancing Green Revolution technologies and the extensive use of land, water, and other natural resources for agricultural purposes. During this time, there has been a notable increase in the physical distance from farm to plate as a result of the extraordinary processes of industrialization and globalization in the food and agricultural sectors.

This has caused food supply chains to dramatically lengthen. Furthermore, all rural settlements save the most remote ones have seen an increase in the consumption of prepared, packaged, and processed goods. But even by 2050, the present rate of advancement would not be enough to end hunger by 2030. For a variety of causes, modern chemical-based agriculture has resulted in lower crop yields and higher production costs (Intawongse & Dean, 2006; Ayansina & Oso, 2006; Sreenivasa *et al.* 2010; Singh *et al.* 2011). Heavy pesticide and chemical fertiliser usage, particularly with regard to heavy metals like Cd, Cu, Mn, and Zn, can pollute the soil profile and seep into groundwater. Plants have the ability to absorb and retain these heavy metals for lengthy periods of time in their edible sections. According to Byrnes (1990) and Barabasz *et al*. (2002), eating these tainted plant items might cause major health issues for consumers. Soil microbial population has declined due to ongoing usage of herbicides such as metolachlor and atrazine. For Indian farmers, the most of whom fall into the marginal and small landholding group, this is especially problematic. India now has 17.76 percent of the world's population (global metre UNDESA, 2020). India's population is expected to increase from 1.2 billion in 2010 to 1.6 billion in 2050, or 10% of the world's population, according to a 2013 UN Department of Economic and Social Affairs projection.

The potential for conservation agriculture exists on around 16% of India's land area; the rest land is unsuitable for cultivation. Therefore, crop production efficiency needs to be raised in order to alleviate food scarcity in highly inhabited places. In light of these problems, a growing number of people are looking for alternatives and consulting traditional agricultural methods. But this is frequently carried out in the absence of solid scientific support and knowledge of the advantages and disadvantages of conventional Indian farming practices.

In reaction to the difficulties facing contemporary agriculture, a number of popular substitutes have emerged, chief among them being organic and natural farming. The goal of these techniques is to lessen dependency on artificial inputs like fertilisers and pesticides by utilising historic ways as inspiration. But it's crucial to understand that although natural and organic farming can have advantages over conventional farming, such better soil health and less of an influence on the environment, they can also have drawbacks and occasionally produce less. Therefore, for their successful implementation, a thorough grasp of their advantages and disadvantages is essential.

In this chapter, we describe role of organic farming and natural farming on environment conservation and soil health.

2.2 Organic Farming on Environmental Conservation:

Organic farming has been practiced for thousands of years in India. Its main goal is to cultivate land and raise crops while protecting the health and vitality of the soil by using biological resources including living things, agricultural products, farm and aquatic wastes, and helpful bacteria that function as biofertilizers. The objective of this strategy is to improve environmentally beneficial, pollution-free output for the benefit of the ecosystem (Sankar and Reddy, 2022). Organic management techniques combine cutting-edge technology with age-old agricultural techniques with an emphasis on conservation to do away with artificial fertilizers and pesticides.

Because more people are becoming aware of the negative effects that conventional farming methods have on the environment and public health, organic farming has become quite popular in India recently. According to Meemken and Qaim (2018) and Gamage *et al.* (2023), organic farming is a sustainable and ethical method of producing food since it offers several advantages to agriculture, people, and the environment. The enhancement of soil health is one of the main advantages. Natural fertilisers, compost, and crop rotation are used in organic farming methods to improve the fertility and soil structure. Produce grown using this method is more nutritious and healthier (Kalainith 2013; Cherlinka 2020). Moreover, producing food free of synthetic pesticides and chemical residues, organic farming enhances human welfare.

According to Mie *et al*. (2017) and Pathak *et al*. (2022), this lowers the chance of exposure to dangerous compounds, enhancing general health and lowering health problems linked to pesticide use. According to Shabir *et al*. (2023), organic farming has a lower carbon footprint than conventional agriculture because it avoids the use of energy-intensive synthetic inputs.

The practice of organic farming has several advantages for the environment and public health, in addition to improving soil health (Smith *et al*. 2019; Adamchak 2023). A farming practice called "organic farming" emphasises the use of ecological and natural processes for raising animals and growing crops. Comparable to conventional farming practices, which primarily rely on synthetic inputs like chemical pesticides and fertilisers, it offers a sustainable and ecologically beneficial alternative.

2.3 Methods of Organic Farming:

Organic farming encompasses a wide array of techniques aimed at sustainable agricultural practices. While crop rotation, livestock integration, cover cropping, agroforestry, aquaponics, and various other methods receive significant attention, their combined benefits contribute to enhancing overall soil health, fortifying resilience to environmental conditions, and promoting sustainable farming practices (Dhiman 2020; Bhujel and Joshi 2023).

2.3.1 Crop Rotation:

Crop rotation plays a vital role in maintaining healthy soils by systematically planting different crops in sequence on the same piece of land. This practice significantly boosts soil fertility, improves pest and disease control, and minimizes weed growth. To enhance soil health indicators like soil carbon, nitrogen, and aggregate stability, integrating perennials such as lucerne into crop rotation systems is essential (Barbieri *et al.*, 2017).

2.3.2 Intercropping:

Intercropping is another valuable technique in organic farming, offering benefits like efficient weed control and increased overall output for farmers. This practice involves concurrently growing multiple crops in the same area, utilizing crop combinations to manage weeds and prevent soil erosion (Pathania, 2020).

2.3.3 Cover Cropping:

Plants known as cover crops are cultivated with the primary aim of improving soil quality rather than for commercial harvest. Within the realm of organic farming, the practice of cover cropping involves intentionally growing specific plant species to protect and cover the soil between the main crop seasons or periods of fallow (Scavo *et al*., 2022).

Numerous research studies have highlighted the positive impact of cover crops on soil health. Future research endeavors should concentrate on understanding the precise timing of nitrogen release from cover crops during their decomposition phase. The sustainability of soil health, conservation of resources, and the advancement of long-term agricultural sustainability all hinge on this eco-friendly approach (Baldwin and Creamer, 2006; Crystal-Ornelas *et al*., 2021).

2.3.4 Biofertilizers:

Bio-fertilizers are defined as mixtures containing living or dormant cells of efficient strains of microorganisms that enhance nutrient absorption by crops through interactions in the rhizosphere upon application to the soil or seeds.

Utilizing diverse microbial strains like algae, fungi, and bacteria, bio-fertilizers play a crucial role in catalyzing specific soil microbial processes to enhance nutrient availability in a form that plants can readily uptake

2.3.5 Livestock Integration:

Livestock integration in organic farming involves the intentional integration of crop and livestock within agricultural systems. This strategy is fundamental to sustainable agriculture as it promotes ecological equilibrium and optimizes resource utilization. Livestock contribute valuable inputs like manure for composting, which enhances soil quality and boosts crop yields.

In return, incorporating crops into livestock grazed areas offers animals a diverse and nutritious diet. Furthermore, certain cattle breeds possess natural pest deterrent qualities, reducing the need for synthetic pesticides. Various studies by Kyomo and Chagula (1983) and Patel *et al*. (2021) have underscored how the mutually beneficial relationship between crops and animals enhances soil quality, reduces waste, and establishes a resilient and self-sustaining farming ecosystem.

2.3.6 Integrated Pest, Weed & Disease Management:

In organic farming involves the implementation of the "PAMS" approach, integrating prevention, avoidance, monitoring, and suppression in pest control measures. Emphasizing preventive and mechanical methods as the primary defenses against pests, diseases, and weeds, producers' resort to techniques like releasing predatory insects or mulching to manage pest and weed populations. As a last resort, producers may seek approval for the use of authorized pesticides from organic certifying bodies to tackle specific pest outbreaks.

2.4 Organic Farming on Soil Health:

Soil health, according to Doran and Zeiss, is defined as the soil's ability to operate as a crucial living system within set ecosystem and land use parameters, supporting plant and animal growth, preserving water and air quality, and fostering plant and animal well-being.

This definition underscores the significance of soil as a dynamic system that sustains vital ecological functions essential for sustainable agriculture and ecosystem well-being. Soil health is an innate feature of soil, encompassing a range of qualities that define its overall well-being and capacity to perform within its ecosystem and land use confines. These attributes play a role in supporting plant and animal growth, as well as in preserving or enhancing water and air quality.

Conversely, soil quality is characterized as an external feature that varies depending on human interactions with the soil. It adjusts according to particular human needs and preferences such as agriculture, wildlife support, watershed protection, or recreational activities. Soil quality is primarily focused on the soil's suitability for specific human purposes and may be evaluated based on factors like agricultural productivity, support for wildlife habitats, water filtration ability, or recreational value (Tahat *et al.*, 2020).

2.4.1 Influence of Organic Farming on Soil Biological Properties:

"Soil biodiversity" refers to the range of organisms found in the, such as plant roots, mesofauna, macrofauna, and microorganisms, many of which are not visible to the human eye. These organisms play crucial roles in various soil functions. As stated by FAO (2020), soil organisms are the main drivers of nutrient cycling, the regulation of changes in soil organic matter, soil carbon storage, and the emissions of greenhouse gases.

They also contribute to modifying and enhancing the physical structure and water systems of the soil, improving nutrient uptake by plants, and promoting plant health. Compost is composed of bacteria, actinomycetes, and fungi, which boost soil microbial activity when introduced as a fresh source of humic material.

Recent research by Kharti and Sharma (2021) suggests that a diverse microbial community is positively associated with soil functions like nutrient cycling and resilience to disturbances. Szostek *et al.* (2022) found that organic farming systems exhibit the highest enzymatic activity and increased biochemical activity due to restrictions on chemical inputs. Wijesinghe *et al.* (2023) demonstrated that the application of organic fertilizers directly impacts the performance of soil enzymes, such as urease, invertase, catalase, and phosphatase, thereby enhancing the soil's microbial environment.

Additionally, agricultural practices significantly impact soil biophysiochemical properties. Soil in organic farming contains higher levels of bacteria, protozoa, nematodes, and arthropods compared to conventional farming methods. Improvements in fertility in organic systems, as evidenced by Balasubramanian *et al.* (1972), promote beneficial soil microorganisms, reduce pathogen populations, increase total carbon content, enhance cation exchange capacity, and decrease bulk densities, ultimately improving soil quality.

Table 2.1: Effects on soil health features of specific organic agricultural systems (Biswas *et al.*, 2014)

Organic Components/ Management	Soil Properties	Effects on Soil Properties	Citation
Organic materials such as FYM, Vermi-compost, Green Manuring, household waste, sewage sludge, and soil organic matter.	Physical	• Improve the soil's airiness, arrangement, capacity to retain moisture, etc.	Altieri and Nicholls, Papadopoulos *e al.* and Jannoura *et al.*
	Chemical	• Plants should be provided with a range of macro and micronutrients. • It is crucial to increase the levels of organic matter and total nitrogen in the soil, as it serves as a vital substrate for cationic exchange and houses most of the nitrogen, phosphorus, and sulfur essential for plant growth.	Bharadwaj and Guar and Parthasarathy *et al*.
	Biological	• The main energy source for microorganisms is soil organic matter, which also enhances the population of microbes within the soil. • Soil microorganisms constitute the living aspect of the organic matter found in the soil. • Organic matter present in the soil has the capacity to assimilate atmospheric CO2, leading to an increase in the soil's carbon content, thereby augmenting respiration and microbial biomass. • Generally, the application of organic fertilizers results in enhanced nodule dry weight (DW), photosynthetic rates, N2 fixation, N accumulation, and N concentration in various crops. • Sewage sludge and household garbage contribute to the	Ewel, Smith and Paul, Lal *et al.*, Dalal Chowdhury *et al.*, Friedel *et al*. Peacock *et al.*, Sparling *et al.*, Poulsen *et al.* and Mattana *et al*

Organic Components/ Management	Soil Properties	Effects on Soil Properties	Citation
		highest concentration of heterotrophic bacteria that form colonies in the soil.	
Crop Rotation	Physical	• The arrangement of various root systems of crops involved in crop rotation influences the soil's physical structure.	Clement and Williams, Chan and Heenan and Grace *et al*.
	Chemical	• Crop rotations significantly increased the soil pH, levels of available phosphate, exchangeable potassium, and calcium.	FAO.
	Biological	• Improving the chemical properties of the soil and enhancing the population of soil microorganisms through crop rotation helps in decreasing the presence of soil-borne pathogens.	Dick and FAO.
Mulching	Physical	• Maintaining the bulk density and air space in the soil is crucial. • Enhancing crop production, soil fertility, and controlling erosion are vital aspects; the decomposition of residues enriches the soil with organic material. • Mulching materials enhance the physical and chemical properties of the soil, regulate soil temperature, reduce water evaporation, and enhance soil moisture content. • This leads to improved water absorption and reduced water runoff in the agricultural fields.	Lampkin, Pinamonti, Naeini and Cook, Lotter *et al.*, GarcíaMorenoa *et al.*, Inyang and Gbadebor.
	Chemical	• The organic matter and nutrients from the	Agbede *et al*.

Organic Components/ Management	Soil Properties	Effects on Soil Properties	Citation
		decomposed mulching materials enrich the soil.	
	Biological	• Mulching supports the soil by improving its biological activity and enriching it with nutrients during decomposition. Additionally, it plays a role in increasing the population, diversity of species, and the vitality of larger soil-dwelling organisms.	Lal, Ojeniyi and Adetoro

2.5 Natural Farming:

Natural farming revolves around the concept of preserving the land's vitality, cultivating wholesome food, and harmonizing with the natural environment. This approach acknowledges that every element in nature plays a vital role in the grand scheme of things.

Referred to as 'Do Nothing Farming,' natural farming views the farmer as a mere facilitator while nature takes on the primary role. It typically involves minimal or no tilling and refrains from using pesticides, chemical fertilizers, or herbicides. Consequently, physical labor is significantly reduced, sometimes up to 80%, compared to traditional farming methods (Devarinti, 2016). Distinguishing itself from organic farming, natural farming, as demonstrated by Fukuoka in Japan, avoids external inputs entirely, including organic manures like farmyard manure (FYM) and vermicompost. Instead, it prioritizes working in sync with nature and adhering to natural methods of crop cultivation. Fukuoka's approach focuses on minimal interference, no-till techniques, and allowing natural processes to oversee crop growth and soil fertility. For instance, Fukuoka experimented with natural pest control methods such as deriving insecticides from chrysanthemum roots to combat cabbage worm and cabbage moth infestations.

Zero Budget Natural Farming (ZBNF), initiated in Karnataka in 2002 and embraced by numerous farming households, aligns with the principles of natural farming. Introduced by Subhash Palekar in India, ZBNF integrates indigenous supplements to promote soil enrichment. Microbial inoculums like Beejamruth and Jeevamruth are incorporated to enhance soil microflora proliferation, aiding in enriching the soil. Additionally, special pesticide decoctions crafted from natural elements like leaves, cow urine, Neemastram, and Bramhastram are employed for pest management. The core philosophy of ZBNF is to nurture beneficial microorganisms and sustain soil health without relying on external manure or chemical pesticides (Khadse *et al.*, 2019; Bruinsma, 2003).

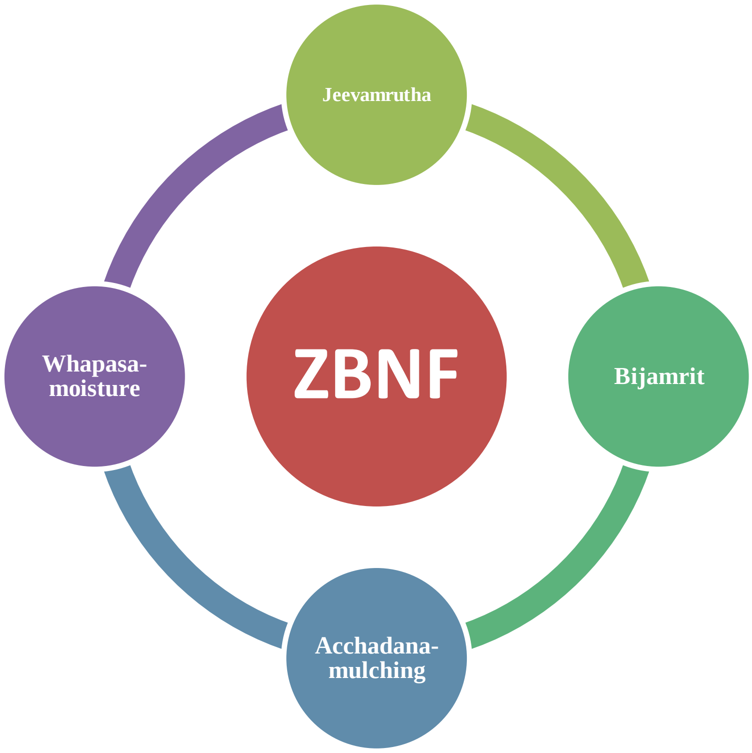

Fig 2.1: Four pillars of ZBNF system (Korav *et al*., 2020)

2.5.1 Jeevamirth:

Soil microorganisms are vital for soil fertility as they play a significant role in cycling essential nutrients like carbon and nitrogen necessary for plant growth (Lazarovits, 1997). They aid in breaking down organic matter in the soil, contributing to nutrient recycling. PGPR, cyanobacteria, and mycorrhiza are key microbial components (Suslov, 1982, Kloepper, 1994) involved in processes such as decomposition, mineralization, and nutrient provision to plants. Phosphate Solubilizing Bacteria (PSB) and mycorrhizal fungi can enhance the availability of mineral nutrients like phosphorus for plants (Katznelson *et al*., 1962, Raghu and Macrae 1966, Khan and Bhatnagar 1977, Rodriguez and Fraga 1999).

Nitrogen-fixing bacteria transform atmospheric nitrogen into soluble compounds that benefit plant growth. These microorganisms enhance soil fertility, promote plant growth, and exhibit antagonism towards pathogens (biological control) as well (Klopper, 1993, Chen *et al*., 1995, Glick and Bashan 1997). While soil harbors essential nutrients, they may not be readily accessible to plant roots. Beneficial microorganisms in Jeevamrith convert these nutrients into soluble forms after being introduced into the soil. Jeevamruth is applied through spraying or sprinkling on crop fields or by adding to the irrigation tank at 15-day intervals until the soil is enriched. According to Mr. Palekar, one local desi cow is sufficient for 30 acres of land, as opposed to Jersey or Holstein cows which carry more pathogens in their dung and urine, unlike desi cows that host 300 to 500 crore effective beneficial microbes.

2.5.2 Beejamruth:

In a container, 20 liters of water, 5 kilograms of cow dung, 5 liters of urine, 50 grams of lime, and some soils are combined and stored. This mixture, known as Beejamruth, is applied as a treatment for seeds, containing beneficial microorganisms naturally found in cow dung. Researchers (Swaminathan *et al*., 2007) have successfully cultured these microorganisms to create Beejamruth, which when applied to seeds acts as an inoculant. Studies (Sreenivasa *et al*., 2010) have shown that treating seeds with Beejamruth not only shields crops from harmful soil-borne pathogens but also promotes the production of IAA and GA, benefiting plant growth.

2.5.3 Acchadana/Mulching:

Three main types of mulch are straw, soil, and live. Planting cover crops such as legumes can help decrease weed growth and improve the soil's ability to absorb water. These crops can fix nitrogen from the air into the soil through their roots, providing a nitrogen boost to other crops. Straw mulching enhances soil moisture and fosters a habitat for beneficial microorganisms and earthworms.

Leaving plant residues on the soil surface speeds up the breakdown process by microbes, releasing nitrogen for plant use. This method also adds organic matter to the soil, rich in various nutrients, thus enhancing soil productivity. Mulching aids in seed sprouting without the need for ploughing, regulates soil temperature, conserves moisture, and prolongs water retention. Removing weeds before they flower and covering bare soil reduces weed infestations and enriches the soil's organic content. This practice eliminates the need for herbicides while promoting sustainable land management.

2.5.4 Whapasa –aeration:

The primary focus here is the conservation of water and the dispensing of water according to the specific water needs of crops. It is recommended to apply water in alternate furrows because not all plant roots are equally effective in absorbing water.

Younger horizontal and vertical roots have a higher capacity to absorb water and nutrients compared to older roots. Within the soil, in addition to mineral and organic components, there exists an equal ratio of water and air. Excessive watering can lead to the saturation of air pockets in the soil, resulting in a lack of oxygen for the plants. This oxygen deficiency can lead to plant death, except plants like rice that thrive in waterlogged conditions.

Adequate soil aeration is essential for optimal plant growth, so prolonging the water application intervals is necessary to facilitate proper oxygen exchange within the soil. The main emphasis lies in conserving water and distributing it based on the specific water requirements of different crops. It is advisable to irrigate in alternating furrows due to the uneven water absorption capabilities of plant roots. Younger vertical and horizontal roots can absorb water and nutrients more effectively than older roots. Alongside mineral and organic elements, the soil contains a balanced blend of water and air. Over-watering can saturate air pockets in the soil, leading to a lack of oxygen for plants.

This oxygen deprivation can result in plant death, except for species like rice that thrive in water-saturated conditions. Proper soil aeration is crucial for optimal plant development, necessitating longer intervals between watering to support adequate oxygen exchange within the soil.

Table 2.2: Difference between organic farming and natural farming (Korav *et al.*,2020)

Sr no	Organic farming	Natural farming
1	Farmlands are supplemented with manures from outside sources, such as oilcake, dung manure, dung slurry, compost and vermicompost, farmyard manure (FYM), and so on	Encouraging the activity of microbes and earthworms to degrade crop residues left on the surface as organic matter helps release nutrients into the soil gradually.
2	However, it still needs the application of fundamental agricultural techniques including tilling, weeding, mixing manures, and ploughing.	Ploughing, soil tilling, applying fertilizers, and weeding are carried out just as they are in natural ecosystems. These practices have been substituted with intercropping, mulching, and planting mixed crops.
3	It needs large, external sources of organic manures, it is still costly and affects the neighboring ecosystems ecologically.	The agricultural system is highly cost-effective and seamlessly integrates with the local ecosystem, without relying on any external resources.
4	It has an impact on the surrounding environment.	It is not environmentally friendly or well-adapted to the local biodiversity.
5	Selling organic items requires certification.	No need for any certification procedures to sell and grow natural products
6	Depending on the condition of the soil, switching from chemical to organic farming may take up to six years.	While switching from chemical to natural farming doesn't take long, it does take time to achieve production and economic stability.

2.6 Conclusion:

The adoption of organic farming and natural farming practices presents significant opportunities for addressing the challenges faced by modern agriculture while promoting environmental conservation and soil health. Organic farming often relies on external sources of organic manures and may take time to transition fully from conventional practices. On the other hand, natural farming integrates more seamlessly with local biodiversity and requires fewer external inputs but may not be as widely recognized or certified. In conclusion, a holistic approach that combines the strengths of both organic and natural farming methods, along with scientific validation and understanding of traditional practices, is crucial for achieving sustainable food production, environmental conservation, and soil health. We may work toward a future in which agriculture provides for the needs of the present without jeopardizing the ability of future generations to provide for themselves by utilizing the tenets of these farming practices.

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