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Organic Farming for Food Security, Soil Health and Ecosystem Resilience under Climate Change

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Abstract
Organic farming plays a key role in enhancing crop resilience, ensuring food security, and improving soil health under the challenges posed by climate change. Organic farming practices such as crop rotation, intercropping, and agroforestry, contribute to crop diversity and resilience against climate change-induced pests, diseases, and extreme weather events. Studies have shown that organic farming can maintain or even increase crop yields, ensure economic profitability particularly in adverse climatic conditions, benefiting local communities. The integration of trees and shrubs in agroforestry systems enhances soil fertility, reduces water stress, mitigates climate extremes, and supports biodiversity conservation. Additionally, organic farming practices improve nutrient availability, reduce nutrient losses, and enhance soil organic carbon sequestration, promoting soil health and improve resource use-efficiency. Furthermore, organic farming prioritizes localized food production and offers nutritional benefits, contributing to improved food security and quality. Overall, organic farming practices present a sustainable approach to address the challenges of climate change in agriculture.

Introduction
In recent decades, climate change has emerged as a significant threat to global food security and soil health. Rising temperatures, erratic precipitation patterns, increased frequency of extreme weather events, and the depletion of natural resources pose challenges to traditional agricultural practices. In this context, organic farming has gained attention as a sustainable approach to mitigate the adverse impacts of climate change on agriculture. Organic farming emphasizes the use of natural inputs, promotes biodiversity, and enhances soil health. This article explores the definition and principles of organic farming and its role in ensuring food and livelihood security and improving soil health under climate change scenario.

Definitions of Organic Farming
Organic agriculture is a holistic production management system which promotes and enhances agro-ecosystem health, including biodiversity, biological cycles, and soil biological activity. It emphasises 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 fulfil any specific function within the system." (Codex Alimentarius Commission, 1999).

Organic Agriculture is a production system that sustains the health of soils, ecosystems, and people. It relies on ecological processes, biodiversity and cycles adapted to

local conditions, rather than the use of inputs with adverse effects. Organic Agriculture combines tradition, innovation, and science to benefit the shared environment and promote fair relationships and good quality of life for all involved (IFOAM General Assembly 2008).

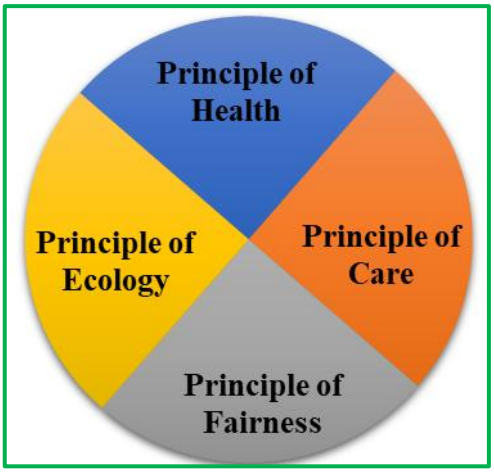
Principles of Organic Farming

Principle of Health: Organic agriculture should sustain and enhance the health of soil, plant, animal, human and planet as one and indivisible.

Principle of Care: Organic agriculture should be managed in a precautionary and responsible manner to protect the health and well-being of current and future generations and the environment.

Principle of Fairness: Organic agriculture should build on relationships that ensure fairness with regard to the common environment and life opportunities.

Principle of Ecology: Organic agriculture should be based on living ecological systems and cycles, work with them, emulate them and help sustain them.



Organic Farming and Food Security

The role of organic farming in ensuring the food and nutritional security under climate change scenario is well explained under following sub-heads:

1. **Enhancing Crop Resilience:** Organic farming practices, such as crop rotation, intercropping, and agroforestry, contribute to crop diversity and resilience against climate change-induced pests, diseases, and extreme weather events. Studies have shown that organic farming can maintain or even increase crop yields, particularly in adverse climatic conditions, ensuring food security for local communities.

a. **Organic Farming Practices and Crop Diversity**: Crop rotation, a common practice in organic farming, involves growing different crops in sequence on the same land. Badgley et al. (2007) highlight that crop rotation can break pest and disease cycles, reduce soil erosion, improve soil fertility, and enhance crop resilience. By alternating crops, the buildup of pests and diseases that specifically target certain crops can be minimized. This practice contributes to increased crop diversity, which is beneficial for maintaining long-term soil health and ecosystem resilience.

b. **Intercropping for Climate Resilience:** Intercropping, the cultivation of two or more crop species simultaneously in the same field, offers numerous advantages in organic farming systems. Badgley et al. (2007) suggest that intercropping can reduce pest and disease pressure, enhance nutrient uptake, optimize resource utilization, and improve overall ecosystem stability. Through species diversification, intercropping reduces the risk of complete crop failure due to climate-related events such as drought or extreme temperatures. It also promotes beneficial interactions between different plant species, resulting in improved pest control and nutrient cycling.

c. **Agroforestry and its Resilience Benefits:** Agroforestry, the integration of trees and shrubs with crops, provides multiple benefits in terms of crop resilience. These systems enhance soil fertility, reduce water stress, mitigate climate extremes, and support biodiversity conservation. The presence of trees in agroforestry systems helps create microclimates that buffer crops against temperature fluctuations and wind damage. Tree roots also contribute to improved soil structure, moisture retention, and nutrient cycling, thereby increasing the overall resilience of the agroecosystem.

2. **Organic Farming and Yields under Adverse Climatic Conditions**: Contrary to common misconceptions, organic farming can maintain or even increase crop yields,

particularly in adverse climatic conditions. Badgley et al. (2007) report that organic farming systems perform as better as conventional systems under normal conditions but better during periods of drought or excessive rainfall. The enhanced soil quality, water-holding capacity, and biodiversity in organic systems contribute to their ability to withstand climatic extremes. Organic farming has a much-reduced carbon footprint because it forbids the use of synthetic pesticides and the majority of fertilisers based on fossil fuels. These agricultural compounds require a lot of energy to produce. According to NRDC (2022), the removal of synthetic nitrogen fertilisers alone which is necessary for organic systems could reduce the direct agricultural sector's greenhouse gas emissions by around 20%. According to a 40-year study by the Rodale Institute, yields on organic farms can be maintained or even increased after a 5-year transition period, while using 45% less energy than on conventional farms (NRDC 2022). Meanwhile, the most potent greenhouse gas, nitrous oxide (N_2O), is released by fumigant insecticides, which are frequently sprayed on crops like strawberries and injected into the soil. According to research, the fumigant insecticide chloropicrin, which is frequently used, can increase N2O emissions by 700–800%. Additionally, Reganold *et al*. (2016) note that organic farming practices, such as compost application and the use of cover crops, can improve nutrient availability and reduce nutrient losses, leading to better crop performance.

3. **Nutritional Benefits:** Organic farming practices tend to prioritize soil health, leading to improved nutrient content and quality in organically grown crops. Research indicates that organic crops contain higher levels of certain nutrients, such as vitamin C, iron, and magnesium, compared to conventionally grown crops. Increased nutritional content can contribute to improved food security, particularly in regions where nutrient deficiencies are prevalent (Popa *et al*., 2019).

- **Economics of organic production:** The analysis brings together results from 40 years' worth of research on 55 crops produced on five continents. Organic agriculture showed to be much more profitable (22 to 35% bigger net present values) and had higher benefit/cost ratios (20 to 24%) than conventional agriculture when actual price premiums (higher prices paid to organic foods) were taken into account. When organic premiums were removed, organic farming's net present values (between 27 and 23%) and benefit/cost ratios (between 8 and 7%) were much lower than those of conventional farming.
- **Localized Food Production:** Organic farming often promotes localized food production, reducing reliance on long-distance transportation and minimizing greenhouse gas emissions associated with food miles. Localized organic food systems can enhance food security by reducing vulnerability to disruptions in global supply chains.
- **Soil Health and resource management:** Soil Carbon Sequestration: Organic farming practices, such as the use of organic fertilizers, cover cropping, and reduced tillage, enhance soil organic carbon (SOC) sequestration. Increased SOC levels improve soil structure, water-holding capacity, and nutrient cycling, thereby promoting soil health and resilience to climate change. Organic farming practices, including the use of organic mulching and cover crops, improve water infiltration, reduce runoff, and enhance water-holding capacity in soils. Effective water management helps mitigate drought risks, maintain crop productivity, and improve soil health, particularly under changing climate conditions.

Conclusion

Organic farming offers a promising solution for ensuring food security and soil health in the face of climate change. By promoting crop resilience, improving nutrient content, reducing greenhouse gas emissions, enhancing soil carbon sequestration, and fostering biodiversity,

organic farming contributes to the overall sustainability and resilience of agricultural systems. Furthermore, the localization of food production and the emphasis on sustainable water management practices strengthen the adaptive capacity of communities. However, further research and investment in organic farming practices are needed to enhance their scalability and cost-effectiveness. Policymakers, farmers, and consumers must recognize the potential of organic farming and support its adoption as a viable strategy to tackle the challenges posed by climate change to global food security and soil health.

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