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# The Significance of Organic Horticulture in Mitigating Climate Change and Promoting the Production of Healthier Fruits and Vegetables

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**Abstract:** Organic horticulture is a holistic management system that follows good production practices and should be considered the cornerstone of mitigating climate change and producing healthier fruits and vegetables. This agroecosystem practice not only benefits the green economy but promotes and enhances soil biological activity, biodiversity, and other biological cycles in the sphere. The last decade has observed a rise in the production and consumption of organically certified agricultural products, and the biggest growth was registered in France (18%) due to its higher nutritional value of vitamin C (27%) and polyphenol content (72%), with a lowered risk of exposure to harmful chemicals of up to 70% and improved organoleptic properties. Between 2012 and 2020, the European Union's organic sector experienced significant growth, with a 56% expansion in organic land area, a 40% increase in organic producers, and a 114% increase in retail sales. The aim of this review was to evaluate the significant impact of organic horticulture on mitigating climate change and meeting consumer needs by examining key research areas, including Soil Health and Management, Pest and Disease Management, Climate Resilience and Adaptation, Carbon Sequestration and Climate Mitigation, Market and Consumer Preferences, and Policy and Institutional Support. The outcome of this review demonstrates that there are still numerous research studies required to evaluate how different farming systems and pedoclimatic conditions can contribute to more efficient horticultural practices.

**Keywords:** conventional agriculture; economic benefits; environmental effects; health benefits; nutrition; organic agriculture; traditional agriculture; vitamin C



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## 1. Introduction

It is well-known that consumers are becoming more conscious of lifestyles that contribute to a low carbon footprint and prefer organic produce [1]. The top three countries that showed massive growth in the organic market in 2021/2022 are Canada (9.7%), Japan (8.4%), and Estonia (6.0%) [2]. The effect of global climate change is one of the greatest concerns faced by mankind in the 21st century. Organic farming provides an opportunity to counteract the effects of current farming practices, such as utilizing synthetic fertilizers, pesticides, and genetically modified organisms by minimizing pollution of the air, soil, and water, and enhancing the health and productivity of interdependent communities of plants, animals, and humans [1]. Organic farming, furthermore, eliminates both chronic and acute exposure of farm laborers, consumers [3], and surrounding aquatic and terrestrial ecosystems to toxic pesticides [4]. In addition, organic produce offers more nutritious products [5], which contain higher vitamin and mineral content [4]. Organic horticultural practices also have a downstream effect on the quality of the produce, which is perceived

to have a better taste due to the higher sugar content and a longer shelf life as a result of metabolic integrity and superior cellular structure [4].

Modern-day horticulture provides many opportunities to incorporate more natural farming practices without affecting yield, with the ultimate aim of higher returns. Integrated and applied organic farming promotes healthy soils and soil microbiota [4], thereby enhancing the availability of nutrients to cultivated plants [6], which offers a more sustainable approach. Organic farming prevents genetic mutations and immune development in insects, an adverse effect associated with pesticide use, thereby potentially reducing pest outbreaks [7] organic farming practices are considered cheaper and more economically competitive as they reduce various input costs associated with conventional farming practices, such as the use of pesticides, herbicides, and synthetic fertilizers [3], whereas traditional agriculture refers to a type of farming that was practiced in the previous years. It is what people used to do to produce food before the discovery of new farming methods and chemicals [8,9]. Like traditional farming systems, closed organic farming systems clearly rely on resources found in nature and within agricultural bodies [10]. This allows for a more harmonious adjustment to nature and, as such, constitutes a privileged ethical strategy for humanity [11].

Climate is described by characteristic conditions such as temperature, precipitation, humidity, soil, snow, and ice cover. The climate is constantly changing due to various natural factors, of which human activity is the most recent and concerning factor that has had an increasing impact on the Earth's climate over the past 200 years. Its impact is defined by the greenhouse effect [12], with temperature changes increasing due to high levels of manufacturing and economic activity, including increases in major greenhouse gas emissions, such as carbon dioxide and methane [13]. Organic agriculture has further demonstrated its capacity to reduce greenhouse gas (GHG) emissions through carbon sequestration and employing fewer inputs. Consequently, in the area of climate change, the transition from conventional agriculture to organic practices is being acknowledged as a viable alternative farming system that holds promise for addressing both climate change mitigation and environmental protection objectives [14,15].

## 2. Organic Farming

Organic farming is a production system that mitigates or largely eliminates the need to use synthetic fertilizers, pesticides, growth regulators, and feed additives and relies essentially on aspects of crop rotation, crop residues, animal manure, legumes, cover crops, non-agricultural organic wastes, and biological pest control (cover crop and insects), which all contribute to maintaining optimal soil productivity, texture, and nutrients to the cultivated plants [16]. This farming technique has evolved into an agricultural system that focuses on resource conservation and recycling, with the aim of building a more sustainable production system [17].

Organically farmed produce is one of the most popular commodities that modern consumers are most interested in purchasing. The organic food market has grown significantly during the past few years (2016–2017), with several countries in the market showing double-digit growth according to the International Federation of Organic Agriculture Movements (IFOAM) and Research Institute of Organic Agriculture FIBL's most recent study, which supports this assertion. The countries with the largest increases were France (18%), Spain (16%), and Denmark (15%) [3,18].

In South Africa, organic farming has a long history, and the country is a founding member of the International Federation of Organic Movements (IFOAM) [19]. South Africa largely supports organic farming, with an estimated organic produce market of between ZAR 200-400 million in 2005 [20]; however, there is currently no comprehensive database to capture the exact number of organic farmers across the country [19]. However, organic certification bodies may be contracted to release up-to-date figures with a real-time breakdown of certified organic certification of fruit and vegetable production.

Organic foods are often perceived as being healthier and having better flavor than conventionally grown crops, as conventional farming practices are usually associated with unwanted residues from pesticides and herbicides. These may accumulate in the soil and certain crops, such as potato tubers, and, therefore, negatively impact organoleptic properties as well as human and animal health [21]. Higher concentrations of nitrates and lutein were found in conventionally farmed potato tubers when compared to organic potato tubers [18]. Despite lutein reportedly being a health benefit for eye health, it may become detrimental when consumed in high amounts, including the yellowing of human skin due to the nature of its pigments as a carotenoid. Furthermore, potatoes from organic production were, on average, richer in polyphenolic compounds, such as phenolic acids and flavonoids.

Organic cultivation practices are rapidly being adopted and are already being practiced in more than 120 countries throughout the world [22]. From a global perspective, organic horticulture is still a niche practice since less than 1% of worldwide farmland is cultivated naturally and since only a small percentage of the worldwide populace is consuming organic produce in noteworthy amounts. Since the generation yields from organic farming practices are moderately low, and the goals of organic farming, according to standards and measures, are not being achieved on most farms, these practices need improvements that are based on scientific evidence and better implementation [23].

Organic farming practices are not without their disadvantages; fruits and vegetables are typically grown in heated greenhouses and require higher energy inputs, contributing to high emissions. In addition, air freight is a large producer of greenhouse gases contributing to a higher carbon footprint, which is of particular concern as most of these products are transported by air. Organically farmed produce is also highly fragile and more prone to spoilage, resulting in large amounts of waste [24].

## 3. Economic Benefits of Organic Cultivation

Whilst organic farming is a system that eliminates the use of synthetic fertilizer on farms by improving agricultural practices that would conventionally utilize hormones, fertilizers, feed additives, and pesticides, it relies heavily on natural methods such as animal manure, crop residues, crop rotation, off-farm organic waste, and the utilization of biological systems for crop protection and nutrient mobilization [25]. This suggests a more hands-on approach to farming and requires more attention to the land being farmed. According to Das et al. [25], organic farming yields more nutritious food that is safe for consumption and reduces input costs at large, and due to the niche market, premium prices can be obtained for organic produce. Premium prices, however, exclude a majority of the global population, which could potentially be corrected earlier on in the production costs. Organic farming assists farmers in running sustainable homes [26], and, in turn, contributes to the overall combating of global climate change. In 2017, it was reported that the number of organic products worldwide was increasing significantly (Figure 1) [25], and in 2022, the statistics report showed that organic agriculture land in hectares (M = millions) in each continent of the world has also increased (Figure 2). Between 2012 and 2020, the organic sector in the European Union (EU) experienced notable growth, with a 56% expansion in organic land area, a 40% rise in the number of organic producers, and a noteworthy 114% increase in the monetary value of retail sales [27]. In addition to the premium prices that can be charged for organic produce, organic certification can indirectly be linked to other economic benefits since certified farmer organizations (or buyers) in developing countries typically provide services, such as price information, training, credit, or value addition, to assist farmers to meet certification criteria and produce the quality demanded in worldwide organic markets. As smallholder access to services is often limited, the additional services provided by certified organizations can assist with the improvement of the smallholder farms, resulting in increased revenue [1,25].

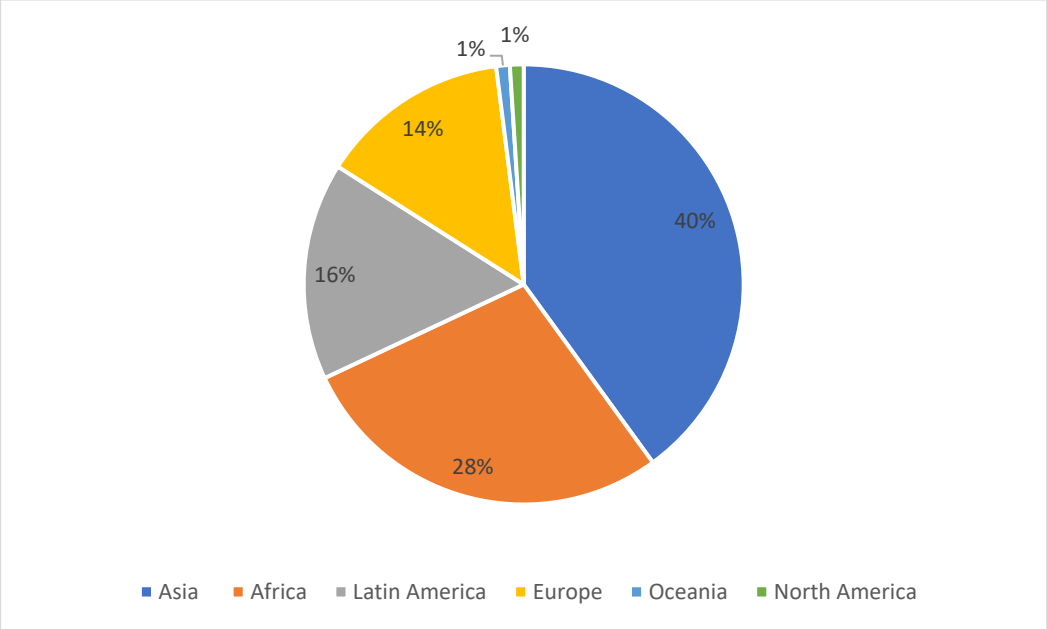


**Figure 1.** Percentage of organically farmed produce by each continent of the world in 2017, adapted with permission from [25].

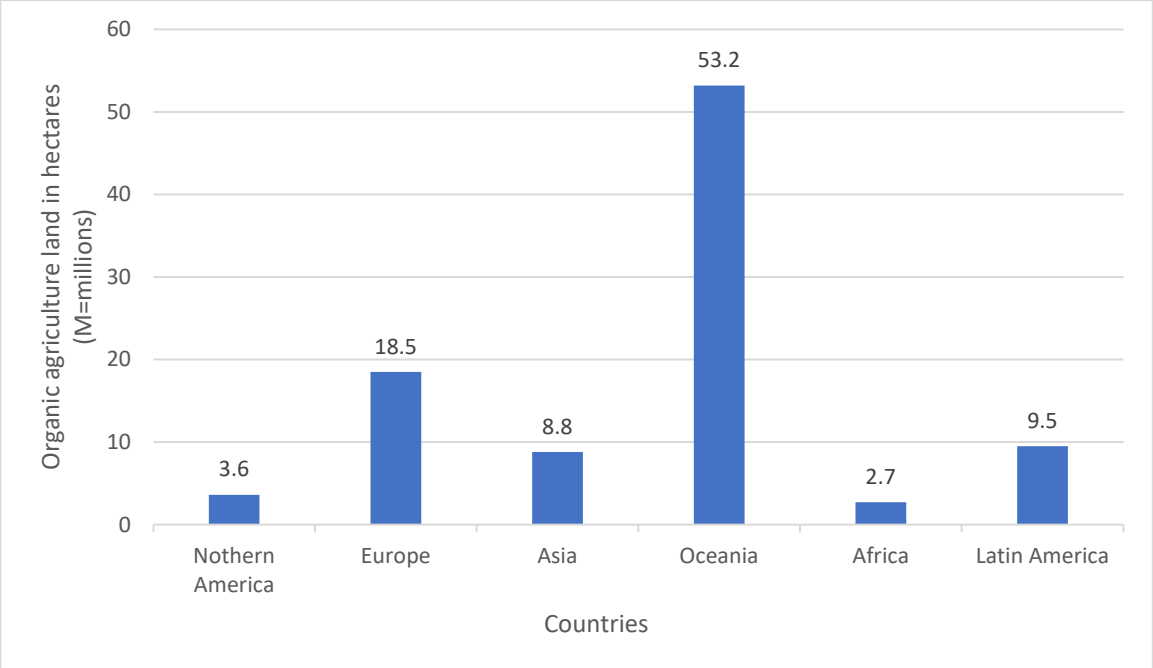


**Figure 2.** Organic agriculture land in hectares (M = millions) in each continent of the world in 2022, adapted with permission from [2].

## 4. Conventional vs. Organic Horticulture

Organic farming and conventional farming are two common management practices in agriculture, which use different methods and practices [26]. Conventional agricultural processes use synthetic pesticides and chemical fertilizers to produce higher yields and profits [25], while organic farming, in simple terms, means the cultivation of plants without the use of synthetic fertilizers or pesticides [26]. Organically produced plant-based foods are often thought to have better health-promoting properties than those produced in conventional or integrated production systems [28]. Organically grown foods, especially leafy

greens, and tubers, have a high dry matter content compared to conventional cultivation methods [25]. Furthermore, conventionally produced plant-based foods and meats are becoming recognized risk factors for both their safety and quality [28].

Organic fortification with organic farming results in nitrogen gas ($N_2$) emissions on the same yield scale as non-organic farming systems. Strengthening organic farming will address climate change mitigation, as organic farming systems are reported to provide greater ecosystem services and social benefits in a larger context compared to non-organic systems. Additionally, organic farming promotes fair labor practices, supports local economies, and enhances social well-being. It also considers environmental, economic, and social equity aspects, promoting a holistic and resilient approach to food production [29].

## 5. Traditional vs. Organic Agriculture

Traditional agriculture, used by centuries of local farming practices [8,9,30], fosters resilience in the face of contemporary challenges and passes the knowledge to the next generation [31]. These traditional methods of farming are a priceless source of information, providing concepts and methods that can strengthen the ability of modern agricultural systems to withstand adverse weather conditions. Traditional farming mostly relies on the natural environment, which is subject to irregular weather patterns and global climate change [32]. The fact that many small farmers adapt to and even anticipate climate change by increasing the use of locally adapted drought-tolerant varieties, water harvesting, mixed cropping, agroforestry, soil conservation practices, and a host of other traditional methods, is the most significant finding regarding the relationships between climate change and peasant agriculture [33]. Crop diversification, maintaining regional genetic diversity, managing soil organic matter, conserving water, and harvesting methods are more strategies included in this list of methods [10].

There are many similarities between traditional agriculture and organic agriculture, as they both depend on natural materials. However, in traditional agriculture, farmers manage risk using experiential knowledge and locally available resources [33], whereas organic farmers lack strategies for risk management; for example, during the dry months, small-scale farmers cannot enter the market, a time when the growing season is for fruits and vegetables [31]. Traditional agricultural practices are usually restricted to small farmers [9]. Evidence has indicated that traditional knowledge is crucial for managing natural resources, maintaining ecosystems, protecting cultural landscapes [32], and managing agricultural productivity [33]. Numerous international conservation programs have emphasized the value of traditional knowledge, which is widely acknowledged. Traditional vegetable knowledge is seriously threatened by factors such as habitat loss, the introduction of new varieties, historical policies, the stigma associated with using traditional vegetables, and altered lifestyles. For example, traditional vegetables grow well in drought-prone locations [9]. The current situation demands that traditional and organic agriculture be integrated.

As already mentioned, organic inputs can reduce GHG emissions [34,35]; also, in traditional agriculture systems, one of the salient features is low energy input [9], which contributes positively to GHG emissions. Farmers who preserve crop genetic resources rely on their traditional agricultural expertise as an essential component of their production process and a method of surviving [36]. Because of their agroecological characteristics, traditional agricultural techniques have the ability to adapt to and reduce the effects of climate change. They enhance the resilience and agrobiodiversity of agroecosystems. They are also inexpensive, energy efficient, and dependent on locally accessible resources. The expertise of traditional agriculture is preserved by indigenous people. In light of climate change, traditional agriculture can be used as a substitute technique for sustainable food production. Traditional agriculture contributes to energy conservation, human health safety, natural resource management, and socio-ecological integrity, in addition to reducing climate change [9].

## 6. Potential Health Benefits of Organically Grown Fruits and Vegetables

Various health benefits are associated with organic farming, such as reduced occupational health risks, as both farmers and farm employees are less likely to be exposed to toxic pesticides and residues [1]. Organic produce appears to have higher levels of health-promoting phytonutrients, vitamins, and minerals. Plant foods with higher concentrations of polyphenols have been shown to be produced through organic cultivation practices and to contain phytochemicals with anticarcinogenic, anti-inflammatory, antibacterial, antioxidant, antihypertensive, immunological regulating, cardioprotective, vasodilatory, and analgesic properties, according to numerous scientific reports [37,38].

Several high-profile meta-analyses published in recent years have challenged the notion that organic foods are healthier, whilst others have found differences between organic and conventional produce that may translate to better health outcomes for consumers, such as higher levels of antioxidants, like vitamin C and polyphenols, lower levels of cadmium (Cd) and pesticide contamination, a lower incidence of antibiotic-resistant bacteria, and less water content (greater dry matter per unit fresh weight) in organic produce [39,40]. Studies have shown that vitamin C was significantly higher in organically versus conventionally produced plant foods [38,41]. Citrus, strawberries, bell peppers, and potatoes are some of the crops that are reportedly high in naturally occurring vitamin C. Tables 1 and 2 show organically produced vegetables and fruits with vitamin C contents. It would, however, be beneficial for tuber crops, like potatoes, to be actively considered for more natural and organic production since it is a global staple food.

**Table 1.** Vitamin C content (mg/100 g) of organically and conventionally produced vegetables.

| Vegetable | Organic Produce | Reference | Conventional Produce | References |
|---|---|---|---|---|
| Potatoes | 68.8 | [42] | 13.50 | [43] |
| Cabbage | 107 | [42] | 27.0 | [44] |
| Spinach | 150 | [45,46] | 28.1 | [44] |
| Beetroot | 20.36 | [47] | 10.21 | [48] |
| Carrot | 5.3 | [49] | 2.9 | [50] |

**Table 2.** Vitamin C content (mg/100 g) of organically and conventionally produced fruit.

| Fruits | Organic Produce | References | Conventional Produce | References |
|---|---|---|---|---|
| Banana | 8.71 | [51] | 8.7 | [44] |
| Oranges | 58.30 | [52] | 53.2 | [44] |
| Raspberry | 174.90 | [53] | 26.2 | [44] |
| Strawberry | 69 | [54] | 58.8 | [44] |
| Mango | 92.8 | [55] | 36.4 | [44] |

A growing number of recent studies have demonstrated the beneficial effects of crop-based foods on human health. The consumption of fruits and vegetables, in particular, has been demonstrated to be useful in preventing cardiovascular disease [56] and more so due to the higher levels of flavonoid expression in organic cultivation. Cereals, legumes, and berries have also been shown to aid in maintaining human health. Their impact can be attributed to a variety of factors. Firstly, crop-based foods are often low in sugar and fat, especially in processed forms, but they are also high in nutritionally beneficial components, such as vitamins [4,57], antioxidants, and bioactive chemicals [36]. Fruit and berry extracts have been shown in vitro to decrease cancer cell proliferation. Thus, elements from fruits, particularly berries, have been shown to inhibit cellular processes associated with tumor growth. Furthermore, extracts from strawberries were found to reduce the rate of cancer

cell growth, with organically grown strawberry extracts showing a higher inhibition of cancer cell growth compared to commercially produced strawberry extracts [36,58].

## 7. Strength, Weakness, Opportunities, and Threats

Conventional and organic horticulture both have unique benefits and difficulties when it comes to producing fruits and vegetables. A SWOT analysis has been carried out to assess the strength, weakness, opportunities, and threats related to each approach in order to provide a thorough comparison. This analysis, which is shown in Table 3, provides insightful information on how organic and conventional horticulture compete with one another by identifying important variables that affect their efficacy, viability, and market potential.

**Table 3.** A SWOT analysis depicting the strengths, weaknesses, opportunities, and threats of organic horticulture compared to conventional horticulture production of fruit and vegetables.

| Factor | Strengths | Weaknesses | Opportunities | Threats |
|---|---|---|---|---|
| Cultivation methods | The exclusion of chemical pesticides, herbicides, and fertilizers leads to lower environmental impacts [58–63] | Requires more land to produce a similar yield to conventional, and it demands more labor [58] | Positive environmental impacts [58] | Adaptation of organic cultivation at a large scale may lead to land use change [64] |
| Product quality | More nutritional, healthier, and safer produce [25,28,37,38,41] | Lower yields compared to conventional production [58,60] | Highly marketable produce [18,27] | Insect, pest, and disease damage to produce [24,65,66] |
| Production yields | Lower yields with improved nutritional value [25] | Lower yields compared to conventional production [58,60] | Lower yields demand higher prices [1,25] | Some consumers cannot afford to buy at higher prices [1,25] |
| Soil fertility | High soil organic matter content, encouraging soil biological activity [67] | Degraded soil can take time to recover [68] | Reduction in environmental degradation [65] | Face similar environmental problems (increased wind, downstream sedimentation, and losses in biodiversity, water quality, and habitat loss) [69] |
| Organic fertilizer | Use of naturally occurring products, such as manure, crop rotation, and crop residues [16] | High prices for organic fertilizers and a lack of organic means [69] | Farmers can use Indigenous knowledge to produce organic fertilizer [68] | The limited supply and variation of organic products in specialized stores [65] |
| Economy | It is highly profitable and increases employment year round [64] | Sometimes a lack of access to financial facilities for organic farming [65] | Government and policymaker involvement can boost organic agriculture's hope for the future [66] | A decrease in organic farmers in certain countries due to the drop in profit during the first years of converting from conventional to organic farming [70] |
| Education | Use of Indigenous knowledge [66] | Low level of farmer literacy [65] | Applying and executing scientific achievements [65] | The weakness of educational and promotional planning [65] |
| Environmental and climate | In organic farming, drought-tolerant crops can be used [32,71] | Reduction in soil organic matter when there is little rainfall [67] | Less rainfall is good for harvesting season [69] | Soil becomes more acidic (salinization) when rainfall decreases [67] |

## 8. Organic Agriculture, Conventional Agriculture, and Traditional Agriculture

The agricultural industry includes a range of farming practices, each requiring different regulatory compliances and methods. The Table 4 below gives a thorough rundown of three common agricultural methods organic, conventional, and, traditional. It draws attention to the essential distinctions and parallels between methods, input use, environmental effects, and conformity to rules and laws.

**Table 4.** Comparisons of traditional, organic, and conventional farming practices and compliances.

| Practices | Compliances | Traditional Cultivation | Organic Cultivation | Conventional Cultivation |
|---|---|---|---|---|
| Historical | Knowledge preservation and development or the advancement of farming practices | Historic farming practices preserving cultural and Indigenous knowledge [8,9,30] | Natural cultivation through crop diversification, genetic diversity, soil organic management, watering conservation, and harvesting techniques [72] | Advancement of modern practices to advance large-scale commercial agriculture |
| Environmental | Legislation and policies | Few to no documented reports | Organic certification in place [1,25] | Food health and safety legislation [73] |
| | $CO_2$ footprint reduction | Very low $CO_2$ footprint [8] | Low $CO_2$ footprint [74] | High $CO_2$ footprint [74] |
| | Fewer chemical residues | Natural and traditional remedies and concoctions [32] | Alternative and organic pesticides and fungicides registered usage | Integrated pest and disease management [75] |
| Cultivation | Meeting food security | Often linked with self-sufficiency and subsistence farming [31] | Reported as alternative cultivation practices and limited large-scale production [76] | Aimed at meeting food security, often overproduction and wastage |
| | Land use | Smaller land use areas often sustainable self-sufficient farming [31] | More land but smaller cultivation areas [58] | More intensive cultivation, more or less land use [59,61] |
| | Volume of production | Lower production [8] | Low-volume production [59,61] | Higher volume of production [59,61,73] |
| | Speed of production | Reliant environmental [32] | Subjected to environmental conditions [3] | Subjected to environmental conditions for open ground or controlled undercover production |
| | Adaptable to various seasons | Open field [32] | Open field or undercover [3] | Open field or undercover [59] |
| Propagation | Accepted or approved methods used | Mainly self-harvested organic seed and traditional vegetative materials and methods used [77,78] | Organic seed and asexual propagation using organic plant material [77,78] | Seed and vegetative propagation methods using commercial seed in conventional farming [77,78] |
| Soil preparation | Minimize destruction of soil profiles | Traditional farming animals (cows and horses) are used to prepare the soil, with plant residues [79] | Reduced tillage with permanent plant cover to establish improved and nurtured soils [80] | Conventional tillage defines soil management practices with mouldboard plowing, followed by secondary cultivation to create a seedbed often degradation of soils [80] |
| Fertilizing and nutrition | Chemical usage regulation | Organic manure used on cropland and traditional fertilizers broadcasted by hand [81] | Animal manure, crop residues, green manure, bio-fertilizers, and bio-solids from agro-industries and food processing wastes [82–84] | Chemical fertilizers are used to provide nutrients to the plants, and they are applied using heavy machinery, boom sprayers, etc. [25,85] |
| Irrigation | Water management | Traditional irrigation systems of flood irrigation and hand watering with the utilization of available sources of water, rainwater harvest, wastewater, and sewage as fertilizer [86–89] | Applications of in-organic agriculture use drip irrigation and overhead irrigation with water conservation strategies through mulching [90] | Conventional agricultural systems use large quantities of irrigation fresh water and fertilizers [91] |
| Weed control | Weed management strategies | Nonchemical weed strategies used in traditional farming, such as crop rotations, cover crops, intercropping, and hand weeding [92] | Increasing seeding rate suppresses the development of weeds through the use of mulch and long-term weed seedbank management [93,94] | Intensive mechanical weeding and chemical weed control [95] |

**Table 4.** *Cont.*

| Practices | Compliances | Traditional Cultivation | Organic Cultivation | Conventional Cultivation |
|---|---|---|---|---|
| | Chemical use application | No chemical use [72] | No chemical use [1] | More agrochemicals used [59] |
| Pest management | | An eradicative method is used in traditional farming [96] | Organic farming employs plant-derived pest control compounds, microbial-based insecticides, and biopesticides derived from organic material for effective pest management [97,98] | Chemical pest control is used in conventional agriculture [99] |
| Disease management | | Field sanitation and the use of clean seeds to reduce the pathogen population size [100] | In organic farming, natural amendments are used, and it also uses biological remedies, physical weeding, and crop rotation to combat disease [101] | Synthetic amendments (fungicides, pesticides) are used in conventional farming [101] |
| Storage | | Traditional storage methods, including tree shade, small huts, straw, leaves, and sorghum stalks, are used for insulation and sun protection, sometimes selling produce immediately after harvest [102] | The storage system utilizes vapor barrier materials, like polyethylene liner, bags, sacks, cloth-coated boxes, and recyclable packaging, for low temperature and high humidity conditions [102] | Storages in organic farming are characterized by low temperatures and high humidity [102] |
| Harvesting | | Manual harvesting [102] | Manual harvesting and machinery use [59] | Manual harvesting and machinery use [59] |
| Packaging and handling | | Packing harvested produce in paper, cardboard, plastic, or recycled bags [103] | Containers like bags, crates, hampers, baskets, cartons, bulk bins, and palletized containers are used [104] | Containers like bags, crates, hampers, baskets, cartons, bulk bins, and palletized containers are used [104] |
| Transport | | Less transportation sometimes is required when selling produce immediately after harvest [102] | Lower transport requirements. Products are often sold at local markets [104] | Large volumes of produce are transported by large trucks [104] |
| Consumers and product marketing | Knowledge | It is safe for human health [31] | Promote a healthier lifestyle. Improve taste [25] | Its products are recognized as risk factors for their safety and quality [28] |
| | Attitude | Not perfect products [31] | Less perfect product (environmental and insect damage) [25] | Perfect graded products [28] |
| | Affordability | Low costs [31] | More expensive [1,25] | Expensive |

## 9. Greenhouse Gas Emissions (GHGs)

The greenhouse effect is defined as the increase in the Earth's surface temperature (lower layers of the atmosphere) caused by the accumulation of greenhouse gases. As a result of this phenomenon, temperatures are higher than normal, causing irreversible effects, such as climate change and global warming [13,61]. Greenhouse gases include water vapor, carbon dioxide ($CO_2$), methane ($CH_4$), and ozone ($O_3$). Carbon dioxide ($CO_2$) is the main contributor to the greenhouse effect (up to 72%) globally. The next most important component is $CO_2$ (9–26%), with $CH_4$ and $O_3$ contributing 4–9% and 3–7%, respectively [13]. The challenge of agricultural development today is not only to meet the demand for food but also to be more environmentally conscious. The global demand for food is expected to increase in the future as the population increases; however, increased food demand in the form of food crops, horticulture, plantations, and animal husbandry has increased productivity, leading to increased GHG emissions, specifically from the agricultural sector [64]. Combined emissions from the agriculture sector account for an estimated one-fifth of the annual increase in GHG emissions. Agricultural production

and biomass burning also contribute to $CO_2$ emissions, as do land-use changes, such as deforestation. Agriculture is also considered a major source of $CH_4$ and nitrous oxide ($N_2O$) emissions, estimated to account for about 50% and 70% of total anthropogenic emissions, respectively [35].

In order to simultaneously achieve increased crop yields and reduce greenhouse gas emissions in small-scale homestead crop cultivation, a variety of approaches are needed, as no single approach can adequately address the complexity of crop production and the challenge of greenhouse gas emissions simultaneously. Adopting different approaches can result in positive synergistic effects that exceed the additive effects of each approach used separately. Nonetheless, due to the lack of scientific data in the field, further efforts are urgently needed, including research and field demonstrations, to identify optimal combinations of different approaches [62].

Carbon dioxide and other greenhouse gases produced by natural processes were present in the atmosphere long before humans played a significant role. These gases have kept the Earth warmer (about 32 °C) than it would have been in their absence by partially blocking the infrared radiation emitted by the Earth [63].

The food system contributes up to 30% of GHG emissions, with agriculture accounting for the largest share of this percentage. In agriculture, livestock is the largest source of GHG emissions, while outdoor horticulture can also have a significant impact. The method by which food is transported, packaged, prepared, and stored can also result in high GHG emissions [24]. Urban food production, such as urban agriculture, community gardens, allotment gardens, and home gardens, is an important part of urban ecosystems since they not only contribute to improving the physical, mental, and social health of people but also the health of the environment. The local food movement has seen growing interest in urban gardens as an alternative to mainstream food systems. Urban food production has the potential to produce food with reduced transport, energy, and packaging intensity and greater carbon sequestration compared to conventional food systems, thus reducing net GHG emissions [70].

Fertilizer discharge and leaching into the environment also lead to environmental problems, such as eutrophication [96]. Several studies have focused on slow-release fertilizers as a solution to reducing groundwater pollution, reducing greenhouse gas emissions, and mitigating the impacts of climate change [105]. Organic inputs, in particular slow-release nutrient pellets and liquid guano, have become imminent in all farming practices due to their risk to GHG emissions.

## 10. Mitigating and Adapting to Climate Change

Some studies report that if crop yields decline due to climate change, the effects on the well-being of subsistence farming households will be severe, particularly if the subsistence component of production declines [41]. Organic agriculture can help with adaptation by increasing water infiltration, which allows soils to absorb most of the rainwater, even during heavy rainfall events by improving water-holding capacity, which promotes plant survival during drought periods. At the same time, organic agriculture can lower fossil fuel emissions by up to 60% compared to conventional agriculture and limit the long-term use of fertilizer and agrochemicals by 20% [41]. However, the greatest contribution that organic agriculture has to offer to climate change mitigation is from carbon sequestration. On average, 79%, that is, 0.1–0.5 tons of organic carbon, can be captured per hectare of land in humid temperate conditions. The most important aspect of the relationship between climate change and organic farming is the realization that many small farmers cope with and even prepare for climate change by increasing the use of drought-tolerant local varieties, water harvesting, mixed cropping, agroforestry, and soil organic practices [41].

Organic systems may significantly lower GHG emissions and hence contribute to mitigating global warming by increasing diversity at the farm level and being included in high-diversity landscapes. Organic farmers who do not utilize agrochemical inputs and, instead, diversify their traditional farms and rural landscapes, could significantly cut

GHG emissions from pesticide and fertilizer production [41]. Organic systems, on average, include more soil organic carbon than conventional systems, notwithstanding the wide range of organic farming practices and underlying concepts. Soil organic carbon benefits from organic farming may only be realized if this management system is combined with larger carbon inputs than in conventional treatments [65].

## 11. Effect of Soil, Water, and Environmental Impact: Organic Farming vs. Conventional

Agricultural practices incur substantial environmental costs, encompassing soil degradation, freshwater contamination, eutrophication, and loss of biodiversity and habitats [102]. In response to these challenges, organic agriculture has emerged as a touted sustainable alternative, characterized by lower environmental impacts compared to conventional high-input agriculture [68,76,85,106,107]. Extensive research indicates that organic farming not only mitigates these environmental costs but also holds potential benefits for soil health. Studies demonstrate that organic farming can lead to higher soil organic matter content and stable aggregation, contributing to improved soil water supply capacity and potentially higher water-limited crop yields compared to conventional farming [85,108]. The positive impact of organic agriculture on soil properties, such as increased organic matter content, enhanced aggregate stability, and reduced bulk density, suggests a correlation with improved ecosystem water relations, emphasizing the multifaceted environmental advantages associated with the adoption of organic farming practices [109].

The environmental consequences of agricultural practices significantly contribute to global climate change, marking agriculture both a contributor and a victim in this complex dynamic. Agricultural activities release substantial amounts of greenhouse gases, making them a contributor to climate change, while simultaneously suffering the consequences of climate-induced impacts on production [110,111]. The adverse effects of climate change on agriculture manifest in various forms, including salinity, drought, heat stress, cold stress, and other abiotic stresses experienced by plants due to climatic factors [112,113]. Climate change exacerbates challenges, such as water scarcity, soil fertility loss, and increased pest infestations, resulting in significant undesirable impacts on crops [112]. Table 5 provides a concise summary of the anticipated effects of individual climate change variables on soil processes. Conventional agriculture is identified as a major contributor to climate change, whereas organic farming is recognized for its comparatively lower environmental and climate impacts when measured per unit of land, though not necessarily per unit of output [1]. This underscores the complex relationship between agricultural practices, climate change, and environmental sustainability.

**Table 5.** Summary of the expected effects of individual climate change variables on soil processes [110].

| | |
|---|---|
| Increasing temperature | Loss of soil organic matter<br>Reduction in the labile pool of soil organic matter<br>Reduction in moisture content increase in the mineralization rate<br>Loss of soil structure<br>Increase in soil the respiration rate |
| Increasing carbon dioxide concentration | Increase in soil organic matter<br>Increase in water use efficiency<br>More availability of carbon to soil microorganisms<br>Accelerated nutrient cycling |
| Increasing rainfall | Increase in soil moisture or soil wetness and enhanced surface runoff and erosion<br>Increase in soil organic matter<br>Nutrient leaching<br>Increased reduction in ions and nitrates<br>Increased volatilization loss of nitrogen<br>Increase in productivity in arid regions |
| Reduction in rainfall | Reduction in soil organic matter<br>Soil salinization<br>Reduction in nutrient availability |

## 12. Challenges and Opportunities for the Development of Plant Organic Farming

Several studies have compared organic and conventional systems and have found that organic systems have lower yields, depending on the crop type and agroecological condition [106,107]. The issue of lower yields in organic farming may be caused by many factors, such as the type of seed used, the environmental conditions of the plants, and many more. There is no availability of certified seeds and other plant materials suitable for organic and low-input farming in many countries, and farmers tend to use inorganic seeds and then follow the organic method to produce their products. Hence, those plants produce less yield because, in nature, they require high inputs to be able to produce good yield. Environmental conditions play a vital role in plant yield, and it is important for the farmers to understand the requirements of the plant and the type of seed they will use, whether or not it is drought-resistant, and many other characteristics before choosing the environment to produce their product in to avoid loss of yield.

One of the main problems facing developing countries is unemployment, particularly for a significant majority of the less-skilled population. Organic farming creates jobs in rural areas since it requires over 15% more labor than conventional farming. Some of the most widely used organic farming methods, like strip farming, nonchemical weeding, and the creation, gathering, and delivery of organic supplements, all call for a substantial amount of labor. The adoption of organic farming in developed countries and for struggling with finances farmers in developing countries may be delayed by a shortage of labor and associated costs. However, labor and its associated costs are not a restriction for countries such as India. Instead, a large portion of rural areas can benefit from organic farming by creating job opportunities [114].

Therefore, differences in the types of work and planting and harvesting timetables may offer more rural women employment options, as well as more evenly distributed and stable employment prospects for males working in agriculture. All year long, farmers and farm laborers are kept busy with crops and mechanical weed control. Conventional farming only offers part-time employment opportunities because more labor is needed in the spring and autumn. As a result, organic farming also takes cost effectiveness into consideration [114].

The progression of organic farming encounters disruptions in its structural dynamics, as evidenced by the cessation of organic practices in some farms and the adoption of such practices in others [115]. In certain countries, the number of organic farms is declining faster than new ones are being established, leading to a reduction in the overall area dedicated to organic crops. For example, in the European Union, the discontinuation rate of organic farming in 2005 was reported to be 7.3% [116]. This highlights the existence of barriers impeding the seamless growth of organic farming, and their identification is crucial for understanding the challenges that may significantly influence future organic farming policies. The formulation of effective policies promoting organic farming necessitates not only the recognition of factors facilitating the adoption of organic production methods but also an understanding of the factors leading to the discontinuation of such methods. One significant prevention for farmers considering organic production patterns is the conversion period, which demands a swift restructuring of their farms. This process involves incurring additional costs related to investments and information access, while concurrently leading to periodic drops in incomes attributable to factors like diminished yields and the inability to command a price premium [117].

## 13. Conclusions

The need for growth in the organic horticulture production systems worldwide is evident. It is not only a requirement for the mitigation of climate change but produces food that is more acceptable for consumers. Organic horticulture can have a remarkable impact on mitigating climate change due to the reduction in carbon sequestration by not using chemical fertilizers that release large quantities of GHGs into the atmosphere. This is notably advantageous to the environment due to no leaching of nutrients and

chemicals that contaminate water bodies in the soil. In addition, it is the second farming system after the traditional farming system that is safe for both the farm workers and the environment since it requires a higher rate of biologically active and safe chemicals than the rate of synthetic chemicals currently applied in conventional horticulture. Many researchers have found that organic horticulture produces healthier fruits and vegetables compared to conventional cultivation. While acknowledging this nutritional superiority, it is essential to recognize the trade-off in yield quantity, with organic farming generally producing lower yields than conventional methods. Organic farmers receive compensation in the form of premium prices for their products, which is a reflection of their dedication to sustainable and health-conscious farming methods. Because of its many advantages, organic horticulture is seen as an essential and long-term solution to the problems that face the environment and modern agriculture. Organic farming offers promising environmental benefits and job opportunities, and addressing challenges related to yield, socio-economic factors, and barriers to adoption is crucial for its sustainable development. Furthermore, the integration of organic farming systems and traditional farming systems would be more advantageous to farmers, the environment, and climate change since these farming systems share many similarities.

The creation of supporting policies that take into account the complexity of organic agriculture and promote the adoption of environmentally friendly methods should be the main priorities of government support for research funding and policymakers. Suggestions are, therefore, made to add a curriculum that includes organic agriculture for primary and secondary schools. Additionally, support should be given to specialized institutes that teach organic agriculture. Higher education in organic agriculture systems should be developed so that organic agriculture can be understood more and obtain the attention and required resources to be at the same level as conventional agriculture in terms of research knowledge and information. Consumers' and growers' education and awareness about the drawbacks of conventional agriculture should be actively promoted. By developing a deeper understanding of conventional agriculture, consumers can make informed choices, contributing towards a more sustainable and responsible food production system. In addition, specifically, African governments must acknowledge the variety of interests represented in the organic sector, making sure that each is fairly taken into account and giving underprivileged groups more consideration. On all levels, governments need to take a proactive role in promoting organic agriculture, and data on organic agriculture need to be recorded yearly in each country throughout the African continent so that the growth and level of it can be known to identify the gaps and opportunities for further actions. There are other developing countries around the world that are succeeding in organic agriculture, such as Turkey, and according to the 2024 statistics, the top three organic producers are India, Uganda, and Thailand. Extensive agricultural systems and the minimal use of agrochemicals make it easy to transition to organic farming, reducing chemical pollution and promoting sustainable practices. Experiences with organic agriculture can be used for defining and improving policy programs, market development, exports, extension services, and research activities in other similar countries.

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