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ABSTRACT

Agriculture and farming have a long history. Agriculture is the main economic structure for many developed and developing countries. The modern agricultural practices affect the environment namely nutrient cycle, soil erosion, carbon sequestration, and many other ecological patterns. Organic farming is influential practice to minimize the environmental and ecological impact of sustainable development. Usage of more organic matters in agricultural practices can reduce the adverse effects on the environment by keep saving its natural cycles on recovery process and organic farming may enhance the food quality too. The organic farming may largely exclude the usage of chemical fertilizers, pesticides, growth hormones and feed additives of livestock activities. A combination of organic farming and new technologies is of utmost importance to reduce the limitations and challenges of organic farming. The innovative methods and new approaches making new trends toward sustainability farming system and enhances the agricultural productivity, and quality of life of many farmers in an environmentally friendly way. In other words, organic farming mirrors the sustainability concepts of Global Agriculture.

1. Introduction

Agriculture is the most basic kind of human activity, encompassing both crop production and animal domestication. Agricultural land is thus the most basic of the world's vast and varied resources, and it is from it that the world's population is fed and sheltered. Although Agriculture's exact beginning is unknown, as the human population developed, fishing and hunting became more important as a means of supplementing what was lacking in the field, and a never-ending search for food ensued. It was apparent that food production was required if human beings were to live a long and secure life. Thereby it is obvious that the importance of agriculture arose from this argument. Agriculture provides a significant proportion of the household economy worldwide. People rely on agriculture to feed their families, earn a living, and start a business, no matter how small (Dorosh and Thurlow, 2016; Abhilash et al., 2021) In affluent countries, agriculture is a less popular source of income, but agriculture benefits everyone in the world, regardless of direct or indirect. As a result of the growing need for agricultural products on a global basis, a variety of job opportunities have arisen. (Mathlouthiet al., 2022). Agriculture is an important part of many people's jobs. The agriculture industry has been a source of income for many individuals in developing and developed countries, with construction programs, drainage systems, suppliers, and more (Bennett et al., 2013). Agriculture has brought a plethora of benefits, and its significance should not be overlooked. It has basic,

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economical, and developmental benefits. It enriches every country in the world in some form while functioning a critical role in both developed and developing countries when it comes to the way of life (Christiaensenet al., 2011; Dubey et al., 2022).

Modern agriculture is an evolving approach to agricultural innovations and farming practices based on the use of high-yielding varieties of seeds, chemical fertilizers, irrigation water, pesticides, etc (Gamage et al., 2022a). Applications of plastics in agriculture are mainly related to crop production and micro-irrigation, forestry, livestock production, and aquaculture and fishery (Gamage et al., 2022b b) (Fig. 1). During the earning process of food safety, people have to face various kinds of natural and manmade hazards. The growing demand for food is not only to fulfill the issues of food security but also to earn foreign exchange. The food manufacturing process has been evaluated from cultivation to distribution for consumers. However, the rapid increase in the requirement for food couldn't be provided by using traditional methods and people have invented more ways over the natural process. But now it has exceeded the natural boundaries of the environment and occurred so many adverse effects due to not following sustainable ways. The cost of environmental quality cannot be sustainable in the future because of the adverse changes being caused to the environment and ecosystem. Resources are limited, but the requirements and ambitions of human beings are limitless and also recovery or regeneration may take thousands/millions of years. Thus, widespread environmental degradation including soil, water, and air pollution, poverty, and concerns about good quality of life were the principal factors for taking interest in future generations' equity, regarding access to natural resources (Table 1). As the best agricultural land has already been farmed and has exceeded the safe limit, the natural resources available for further farming expansion are practically exhausted. The necessity of having an alternative agriculture method that can be functioned in a friendly Ecosystem while sustaining and increasing productivity. Organic farming is recognized as the best-known alternative. It is economically feasible to practice when the farmers can get a premium price for their product. The widespread challenges organic growers face includes lower yields, difficulty maintaining soil fertility levels, gaining proper certifications, and market access. A combination of organic farming and new technologies is of utmost importance to reduce the limitations and challenges of organic farming. The innovative and sustainable approach of organic farming enhances the agricultural productivity, and quality of life of many farmers in an environmentally friendly way. In this review, agricultural pollutants and their impacts, sustainable development and organic farming, challenges and limitations of organic farming are mainly considered and will give information about new innovation technologies improve the application efficiency of organic fertilizers as well as use efficiency of organic farming.

2. What is organic farming?

According to the definition by the United States Department of Agriculture (USDA), the term organic farming refers to "a system which avoids and largely excludes the use of artificial inputs" (e.g., fertilizers, pesticides, hormones, feed additives, etc.). Organic farming depends upon crop rotations, crop residues, animal manures, off-farm organic waste, mineral-grade rock additives, and biological systems of nutrient mobilization, ensuring plant protection optimally. "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 "(Organic Farming | NRCS. (n.d.).

Organic farming increases the ability to face the adverse effects of climate change by increasing resilience within the agroecosystem. It creates potent and environmentally sound farming systems that are resilient to temperature fluctuations, and drought and which avoid soil

Protected cultivation	Nets	Packaging	Piping, irrigation / drainage	Other
Greenhouse and tunnel (high and low tunnels)	Covering vineyards and orchards	Seeds and planting packaging	Channel lining	Silage films
Mulching	Wind breaking	Agrochemicals cans	Irrigation tapes and pipes	Fumigation films
Nursery covering films	Shading	Containers for harvesting and storage	Drainage pipes	Grafting and layering tapes
	Nets for harvesting	Tanks of liquid storage	Micro irrigation	Bale wraps
		Crates	Drip irrigation tubes	Nursery pots
				Strings and ropes






Fig. 1. Applications of plastics in agriculture (Gamage et al., 2022b).

Table 1
Types of Agricultural pollutants and their impacts.

Types of Pollutant	Source	Effect	References
Soil			
Salts	Irrigation water	Inhibiting seed germination; reduced growth rate; foliage discoloration and disfiguration; growth of halophytic plants; waterlogging	Mohanavelu et al. (2021); Thaker et al. (2021)
Heavy metals and nutrients	Pesticides and chemical fertilizers	Human health: can cause skin cancer, liver and kidney damage	Singh et al. (2017); Briffa et al. (2020); Gavrilescu (2021); Sharma et al. (2021); AL-Huqail et al., 2022; de Carvalho et al. (2022); Gamage et al. (2022a); Xu et al. (2022)
Nondegradable plastics	Crop production and micro-irrigation, forestry, livestock production, and aquaculture and fishery.	Combustion of agricultural plastic wastes −1.volatile toxic emissions effects on human health, −2. ash-change the composition and pH of the soil.	Solomon-Wisdom and Ndana (2012); Dwivedi et al. (2019); Szajner et al. (2021); Gamage et al. (2022b)
Manure	Animal and domestic wastes	Plant diseases	Maria, 2021; Gamage et al. (2022b)
Water			
Biological or infectious agents	Animal and domestic wastes-Pathogenic bacteria, yeasts, and protozoa; parasitic worms; viruses; fungi, algae, some crustaceans, and insects, etc.	Infectious diseases	Maria, 2021
Biodegradable organic compounds and oxygen-demanding wastes	Organic wastes-biodegraded by aerobic microorganisms	Effect on the water quality by microorganisms; can cause color, taste, and odor problems	Bala et al. (2022); Policastro and Cesaro, 2023
Nonbiodegradable organic compounds	Industrial effluents, runoff from farms and yards; pesticides, organic solvents, oil with its refining and processing products, tannins and lignins, cellulose and phenolic compounds	Effect on Human health fish and wildlife	Xuqing et al. (2016)
Inorganic chemicals	Industrial effluents, surface runoff, pesticides; water-soluble acids, heavy metals; increase salinization	Effects on drinking and irrigation water; human health,(fish and wildlife; reduces crop yields; metals corrosion exposed to contaminated water	Singh et al., 2017; Briffa et al., 2020; Gavrilescu, 2021; Sharma et al., 2021; AL-Huqail et al., 2022; de Carvalho et al., 2022; de Xu et al., 2022; Gamage et al., 2022a; Rad et al., 2022;
Plant nutrients	Chemical fertilizers and organic wastes (manure, biosolids),	Eutrophication -effects on the aquatic life	Fageria, 2007; Atwell and Bouldin, 2022; El-Ramady et al., 2022
Sediments	Erosion, runoff soil, silt, and other solid matters.	Reduce photosynthesis (due to water clouding); disrupt aquatic food webs; transport pesticides, bacteria, and other harmful substances; destroy feeding and spawning grounds of fish; clog lakes, reservoirs, channels, harbors	Maria, 2021; Atwell and Bouldin, 2022;
Air			
Carbon dioxide	Food processing plants; burning of agricultural wastes; agricultural machinery	Climate change-Global warming;	Szajner et al., 2021
Methane	Crop production and livestock; animal feed production; food processing; agricultural residues	Climate change-global warming	Szajner et al., 2021; Xu et al., 2022
Nitrous Oxide	N fertilization; management of manure, burning of agricultural residues.	Climate change-global warming	Szajner et al., 2021; de Carvalho et al., 2022; Xu et al., 2022

erosion. Organic farming also promotes sustainable and environmentally friendly management, conservation practices, and restoration activities. The financial need for organic farming is low compared with modern agriculture. Furthermore, organic farming helps farmers and communities to adapt to the susceptible effect of climate change. In addition, organic farming fulfills many of the requirements identified for successful adaptation strategies (Muller, 2009; Murmu et al., 2022) (Fig. 2).

Organic farming provides solutions for most problems faced by contemporary issues in agriculture and food Production. The principles of health, ecology, fairness and care are the roots from which organic agriculture grows and develops. Organic products are richer in nutrients and largely free of pesticide residues and additives (Hammed et al., 2019). Organic farmers are aware that health by avoiding chemical pesticides and fertilizers commonly used in farming (Pandiselvi et al., 2017). Organic livestock practices produce animal products without antibiotics and other drugs. It helps slow the growing health crisis retarded by the dangerous spread of antibiotic-resistant bacteria. Organic farmers promote and manage biodiversity, increased populations of natural enemies (helps control pests and diseases without chemicals), improved natural resources such as soil, water, air, and wildlife, and support pollinators, which are essential to maintaining a healthy environment as well as producing healthy foods (Merrigan et al., 2022). Organic products have a lower level of pesticides and nitrates.

3. Positive and the negative impact green revolution

Most of the countries increased food production and attained self-

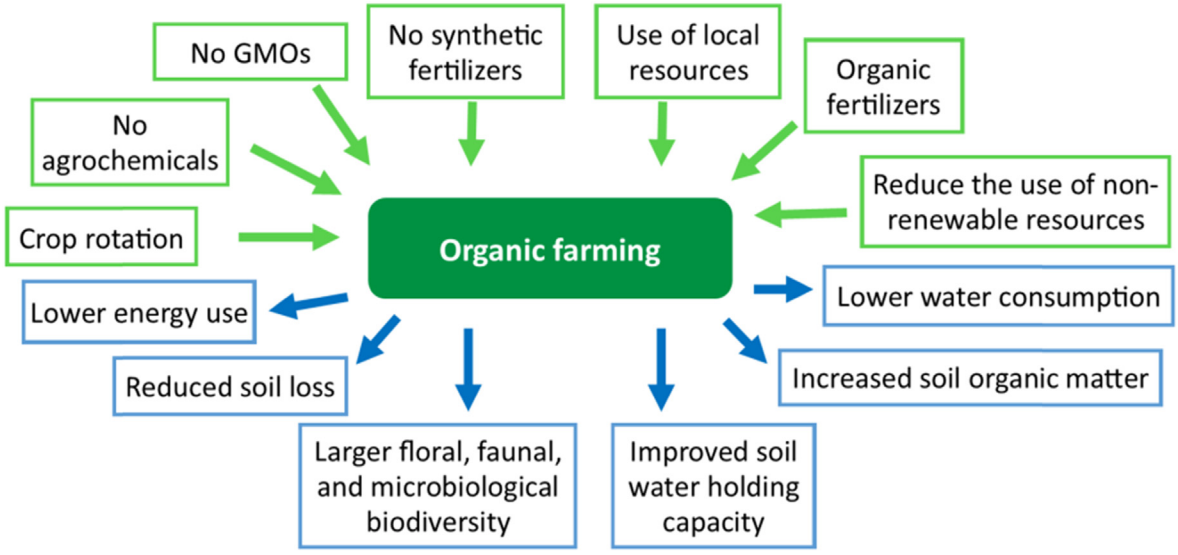

Fig. 2. The main practices and effects of organic farming.

sufficiency and High income with the green revolution. Furthermore, it enabled some countries to shift from a Food deficit to a food surplus creating opportunities to export food products (Kansanga et al., 2018). However, while achieving the aforementioned goals, most countries had to consume less nutrient food with polluted water due to fertilizer and pesticide usage for high productivity. Moreover, the following are also considered negative aspects of agriculture due to the green revolution.

Reduction in natural fertility of the soil, destruction of soil structure, erosion and soil loss of killing of beneficial microbes and insects, groundwater pollution and depletion, atmospheric pollution, soil acidification, chemical burn, and mineral depletion. As a result, the health effects of conventional farming raised day by day. Asthma, birth defects, neurological effects, cancer, Hormone disruption, and Parkinson's disease are the most health effects of conventional farming. The high use of inorganic fertilizers for farming is attributed to high nitrate levels in groundwater. The availability of suitable groundwater is a significant factor in the maintenance of life. Infant methemoglobinemia and various types of human cancer are caused due to nitrate-contaminated drinking water, which is also well-known as a risk factor for cancer. Studies conducted in Kalpitiya (Liyanageet al., 2000) have shown that only 56% of wells contained safe drinking water (based on WHO standards) is due to high nitrate. The study also reported high concentrations of nitrate in some vegetables (Anguna, Kurathampala and long beans). This high contamination of nitrate nitrogen in agro wells due to the intensive use of inorganic fertilizer in permeable soil with shallow groundwater. Contemporary issues in farming are the decline in the fertility of the soil and the fall in productivity levels. The use of chemical fertilizers and synthetic pesticides determines soil health as well as causes harm to our natural ecosystems by polluting our environment and water. To make sure that future generations are secure from these negative consequences, it is a timely need to shift towards organic farming and restore soil fertility and maintain soil fertility on a sustainable basis (Geissen et al., 2021).

Organic farming is one of the fastest-growing sectors in agriculture, contributing to 1% of the world's agricultural area. It is a farming system that uses fertilizers of organic origin such as compost manure, green manure, and bone meal and places emphasis on techniques such as crop rotation and companion planting (Seufert et al., 2017). Organic agriculture is not a new vision in most Asian countries. Specially Sri Lanka used to export rice to other countries using the organic farming system in ancient times. It originated early in the 20th century in reaction to rapidly changing farming practices (Kulasooriya et al., 1994). Organic farming plays the main role in the sustainability of agricultural systems. Sustainable agriculture is a broad term for growing food using methods that will nurture society, the environment, and the economy. Sustainable farmers seek to support community health and well-being and to work with nature, while still being profitable businesses as well as functioning as non-profits or recreational projects. Sustainable farming is important because it offers solutions for the contemporary issues of traditional farming. Soil is considered a nonrenewable resource, sustainable farming promises to protect and preserve soil health. Furthermore, it addresses most of the public concerns, including Corrective measures to continue health disparities among people of color, and reforming industrial practices, such as reducing the use of antibiotics where the production and processing conditions can be harmful to human as well as animal health (Ebitu et al., 2021). The sustainable farming motion creates room for a food system that admires the dignity of farmers and hirelings. Using non-renewable energy resources is the foremost cause of climate change, and food production is a primary sector contributing to greenhouse gas emissions. Sustainable farmers seek to be careful in using such resources, in alignment with their goal of protecting the environment. When we observe the organic farming system and the sustainable farming system, we can see both have more similarities. As a country and a nation, we should move toward organic agriculture. However, this cannot do in one night because we polluted our farming system with the green revolution. When the population increases day by day we should concern about the high productivity—green revolution response to this problem. The current generation should think about the next generation. We should protect soil fertility for the next generation; at the same time, we cannot put the current generation in the mouth of hunger. As a country, we can generate the best policies considering both aspects. Then we can see how organic farming works in the sustainability of agricultural systems in any country.

4. Modern agriculture to organic farming

The environment and people are impacted differently by modern agriculture and organic farming methods. Increased greenhouse gas emissions, land erosion, water pollution, and human health are significant consequences of traditional agriculture. Organic farming reduces carbon emissions, improves soil health, and reloads natural ecosystems for cleaner water and air, all while avoiding hazardous pesticide residues. The primary distinction between organic and conventional farming is that conventional farming depends on chemical involvement to combat pests and weeds, as well as to supply plant nutrients. Synthetic pesticides, herbicides, and fertilizers are included in this category. At the same time,

organic farming produces healthy, abundant food by solely relying on natural principles such as biodiversity and composting. "Organic farming production" is defined as not merely avoiding conventional chemical inputs or substituting natural inputs for synthetic ones; it also uses strategies that have been practiced for thousands of years, such as crop rotations and the utilization of composted animal manures and green manure crops, in ways that are economically feasible ways today. The interaction of management methods is the primary issue in organic production, which emphasizes overall system health. Organic farmers use various techniques to increase and sustain biological diversity while maintaining high soil fertility from time to time (Walmsley and Sklenička, 2017).

4.1. Organic farming practices in the global agriculture

Organic farming is practiced in 187 countries, with at least 3.1 million farmers operating 72.3 million hectares of farmland organically (Willer et al., 2021). Organic food and drink sales in 2019 totaled more than 106 billion euros worldwide, showing the high interest of contemporary people getting used to healthy and environment-friendly eating habits: being health conscious. More than 75% of the world's agricultural production is produced through certified organic farming. It is one of the most prolific and cost-effective agrarian systems in the world. In terms of the number of producers, India was the world's biggest producer of organic foods in 2019 (Willer et al., 2021). India had 1.4 million organic food producers in that year, which was more than the combined number of organic food producers in the world's other nine largest countries (Willer et al., 2020). Organic farming is typically seen to be more sustainable than conventional farming, yet it comes with its own set of problems and opportunities. Organic farming is less polluting than conventional farming in terms of environmental and climate change effects (Sean, 2020). On average, organic farming produces lower yields. If more farmers transition to organic practices, the observed production differences may widen even more due to higher expertise requirements. Organic agriculture's widespread upscaling would result in further loss of natural habitats as well as higher output prices. Organic farming isn't necessarily the best option for long-term agriculture and food security, but judicious mixtures of organic and conventional practices could help boost global agriculture output (Meemken and Qaim, 2018). The principles of health, ecology, fairness, and caring are the bases of organic agriculture. They highlight the positive impact that organic agriculture can have on the globe and a worldwide ambition to better all agriculture. Organic food is becoming increasingly popular. Consumer concerns about the harmful effects of conventional agriculture on human health and the environment are largely to blame for the rising demand. Most people, particularly in industrialized nations, believe organic food is safer and healthier than conventionally produced food (Yiridoeet al., 2005). Organic farming is generally seen as better for the environment, climate protection, and animal welfare by rich consumers (Seufertet al., 2017).

4.2. How organic farming contributes to sustainable development

One of the main advantages of producing organic food is that farmers can reduce greenhouse gases, such as methane and nitrous oxide, cast into the atmosphere. It also preserves culture and agriculture while providing healthier food sources. A survey led by researchers at the University of California, Davis, revealed that food produced by organic methods contains up to 58% more polyphenolics (an antioxidant) than conventionally grown food (Fell, 2003; Faller, 2010). The researchers concluded that the higher levels of polyphenolics, which plants use as a natural defense system, could be attributed to the more significant number of pests they must fight. It is another way of saying that pesticides and herbicides could lower a plant's rate of phenolic production. The synthetic fertilizers that many farmers use also require many fossil fuels during the manufacturing process, so less synthetic fertilizer means fewer fossil fuels are being burned. Chemical fertilizers threaten the environment, and chemicals can often enter local ecosystems, harming animals and polluting rivers. Organic farming does not pose such risks to the natural environment. One of the main reasons for farming is to protect and maintain the health of the soil. To do this, farmers use nutrient-rich composts containing only organic materials, add minerals like rock phosphate and greensand, and practice crop rotation. Most people have an awful perception of pesticides and other chemicals being used in the food they will be eating; therefore, producing organic food can ease consumer fears and increase consumption. Water has been another big issues become lately. Because no chemicals are used in organic farming, the possible groundwater contamination is nonexistent. Ample opportunities for rural jobs, and fewer external costs for unnecessary pesticides, fertilizers, etc (Chaichi et al., 2018; Merah et al., 2021; Mohammedi et al., 2022). Those are the main advantages of organic farming (Zhou and Ding, 2022).

Ending world hunger, achieving food security, and promoting sustainable agriculture are the main targets of sustainable development goals (SDGs). When the SDGs are taken as a whole, Agriculture is contributing to all the 17 sustainable goals either directly or indirectly (Lu and Wu, 2022). For instance, we cannot end poverty without ensuring food security. To achieve the second goal of the SDGs, there should be sufficient, safe, and affordable food for all. Good health starts with good nutrition. We cannot provide quality education without any nutritious food since nutritious food is critical to learning. Gender equity could boost agricultural productivity. Because if any country has an economic crisis most of the time they feed according to gender. Sustainable agriculture has the potential to address water security. When people eat healthy food, they think about clean water and sanitation (Linderhof et al., 2021). Organic agriculture helps to overcome dependence on fossil fuels. Most people like to have decent work when agriculture grows low, it affects the economic growth of most agriculture-based countries (UNEP, 2011). Industry innovation and infrastructure facilities will increase with customer-friendly agricultural products. Land reforms can give fairer access to rural land. When organic farming is practice in any community, they will be healthy physically, mentally, and economically. Achieving Food security involves reducing waste. Best agriculture practices are key in responding to climate change. Fish provide 20% of daily animal protein. Forests contain over 80% of the world's terrestrial biodiversity (Ukhurebor and Aidonojie, 2021). If any in risk to food security, there are so many conflicts between the poor and the rich. Ending hunger can contribute in a high position to establishing peace and justice and strong institution. It is evident how organic agriculture contributes to sustainable development goals. One major disadvantage of organic farming is the high costs and time consumption in the process. It might not be sustainable/profitable. Many studies conducted on organic farming have concluded that the yields provided are not productive enough to be profitable. The researchers found that organic yields were 25% lower than those of conventional farming (Roberto, 2022). This is what Sri Lankan experience these days with improper policy interventions, which resulted in a reduction in productivity. Farming can be a lot more labor-intensive, and the cost of organic feed is much higher than non-organic feed. These costs are passed on to the consumer making organic food more expensive to buy than conventionally produced food. Whilst many people are more than willing to pay more for their food because it is organic, during times of hardship and recession, people are less likely to buy organic when they can get the same food for a cheaper price. Organic farming also requires far more land to grow the same amount of produce as conventional farming does because chemicals are not used to produce high-yield crops. Sustainable agriculture adopting Agroforestry Practices. They were applying Integrated Pest Management. Farmers can use biological and mechanical methods to keep unwanted animals and insects from their crops. Chives, sage, and mint plants are natural insecticides, that can use as biological pest control. Aquaponics is when people grow fish and vegetables in a mutually beneficial system sharing water and nutrients. Hydroponic farmers grow plants using fertigated water. They grow plants without soil

and instead use materials like clay balls, coconut hair, and fabric. Sustainable farmers avoid soil erosion. Farmers can take care of the ecosystem by minimizing their use of fertilizers and pesticides so that runoff from their farms does not contribute to water pollution. Instead of using sprinklers, for example, farmers seeking to conserve water can adapt to drip irrigation to irrigate their plants. Cover crops to help them to handle manure and to graze tame animals like cows, goats, and sheep. When study about sustainable development goals and sustainable agriculture can imagine how organic farming works for sustainable development. Table 2 summarizes the organic farming and the Sustainable Development Goals (SDGs).

4.3. Agricultural sustainability

Agricultural sustainability is based on the idea that we must meet current needs without jeopardizing future generations' ability to meet their own. In agriculture, sustainability has a wide range of uses (Malik et al., 2020). Agriculture has a huge environmental imprint, contributing to climate change, water scarcity, water pollution, land degradation, deforestation, and other processes; it is both causing and being influenced by environmental changes (Mateo-Sagasta et al., 2017). Sustainable agriculture refers to farming practices that do not harm human or environmental systems while producing crops or livestock. It entails avoiding negative consequences for soil, water, biodiversity, nearby or downstream resources, and those who work or live on the farm or in the surrounding area (Etingoff, no date). Sustainable agricultural components can be found in a variety of places. Sustainable agriculture practices include permaculture, agroforestry, integrated farming, multiple cropping, and crop rotation. It is critical to building flexible business processes and farming methods while developing agriculture within sustainable food systems (FAO, 2018a). The development of sustainable food systems aids the human population's long-term viability. The development of sustainable food systems helps the human population's long-term viability. Building sustainable food systems based on sustainable agriculture, for example, is one of the best strategies to alleviate climate change. Sustainable agriculture also offers a way for agricultural approaches to support an increasing population while adapting to changing environmental conditions. In agriculture, sustainable agriculture balances three considerations, namely, environmental, social, and economic.

4.4. Sustainability in global agriculture driven by organic farming

Agricultural practices need to change to meet the United Nations Sustainable Development Goals by 2030. Sustainable agriculture and food systems need to provide sufficient and nutritious food for all while minimizing environmental impact and enabling producers to earn a decent living (FAO, 2018b). Most agree that agriculture and food systems urgently need to change to make progress on several Sustainable Development Goals (SDGs) while staying within planetary boundaries. However, the way to achieve this is intensely debated, with two narratives dominating the discussion: incremental steps to improve efficiency in conventional agriculture while reducing negative externalities versus transformative redesign of farming systems based on agroecological principles.

According to the statistic given by the Research Institute of Organic Agriculture FiBL the Oceania region includes Australia, New Zealand, and the Pacific Island states. There were over 18,000 producers, managing almost 36.0 million hectares. This consists of 9.7 percent of the region's agricultural lands and half of the world's organic land. More than 99 percent of the organic land in the region is in Australia (35.7 million hectares, most of which is extensive grazing land), followed by New Zealand (almost 89,000 ha) and Samoa (14.5%), followed by Australia (9.9%), Fiji (5.5%) Vanuatu (4.5%), Solomon Island 3.5%) and French Polynesia (3.4%). Four countries in Oceania have legislation on organic agriculture, and twelve countries have a national standard but no organic

Table 2
Organic farming and the Sustainable Development Goals (SDGs).

SDGs	Themes	Functions
1	End poverty	Provide incomes for organic farmers, low cash costs suitable organic farmers, sustainable production (crops and livestock), higher incomes from premiums of organic farming products and labor-intensive nature
2	End hunger, achieve food security, improved nutrition, promote sustainable agriculture	A diversified cropping system-it helps to mitigate risks of crop failure, more nutritious and safe food, improved productivity and sustainability of productive systems, and helps protect genetic resources
3	Ensure healthy lives and promote well-being for all at all ages	Improved Health and promotes healthy lifestyles
4	Ensure inclusive and equitable quality education for all	Effect of spending more money on children's education
5	Achieve gender equality and empower all women and girls	Providing more opportunities for employment of women, labor-intensive nature provides safe local employment for women, avoiding migration to urban areas for work and it will improve the well-being of the family.
6	Ensure availability and sustainable management of water and sanitation for all	Less fertilizer leaching, which reduces pollution of water bodies by chemical fertilizers and pesticides, the indirect effect of improved access to safe water and sanitation (reduce nitrates, phosphates pollution, heavy metal pollution, and agrochemical pollution)
7	Ensure access to affordable, reliable, sustainable, and modern energy for all	Integrated Farms and incorporate organic principles
8	Promotesustained, inclusive, sustainable economic growth, full and productive employment, and decent work for all	Organic agriculture provides a safer and healthier work environment and sustainable livelihood
9	Buildresilient infrastructure, promote inclusive and sustainable industrialization, and foster innovation	Modernization of organic farming could provide training and facilities for farmers (certification, traceability, marketing, harvest, and postharvest technologies)
10	Reduce inequality within and among countries	Integration of small organic farmers into Global Markets. It will ensure sustainable consumption and production patterns
11 and 12	Make cities and human settlements inclusive, safe, resilient, and sustainable; Ensure sustainable consumption and production patterns	The growth of ethical consumerism has increased the support of consumers for crops produced in environmentally safe and socially responsible production. Community-Supported agriculture reduces waste and promotes recycling
13	Take urgent action to combat climate change and its impacts	Organic farming practices mitigate climate change.
14	Conserve and sustainably use the oceans, seas, and marine resources for sustainable development	Reduce water pollution
15	Protect, restore, and promote sustainable use of terrestrial ecosystems, sustainably manage forests, combat desertification, and halt and reverse land degradation and halt biodiversity loss	Organic practices promote restoring carbon in soils, improving degraded lands, and producing healthy food.
16	Promote peaceful and inclusive societies for sustainable development, provide access to justice for all, and build effective,	Agribusiness firms as partners in the development

(continued on next page)

Table 2 (*continued*)

SDGs	Themes	Functions
	accountable, and inclusive institutions at all levels	
17	Strengthen the means of implementation and revitalize the global partnership for sustainable development	

(WHO, 2022; FAO, IFAD, UNICEF, WFP and WHO, 2022; Srđan Šeremešić et al., 2021; Setboonsarng and Gregorio, 2017; SetboonsarngMardandya, 2015)

legislation. Australia becoming successful in organic farming day by day. They achieved this by facing so many disasters in the country (Denyeret al., 2012). Their approach provides a good lesson for other countries too.

4.5. Sustainable development and organic farming

Agriculture is widely recognized as a critical component of long-term notified sustainable development. Small-scale farmers in poor countries must be included in the transformation of agrifood systems to meet the Sustainable Development Goals by 2030, as a direct hit (FAO, 2018b). Agriculture is at the heart of Goal 2 in the 2030 sustainability agenda, which strives to eliminate hunger. But to varying degrees, the agricultural sector is also involved in all other Sustainable Development goals. The first Green Revolution arose in reaction to rising numbers of undernourished and malnourished people, allowing agricultural technologies like pesticides and fertilizers to spread to emerging countries. The early sustainable farming methods were implemented during this time, even though they were seemingly not applied (Pingali, 2012). Even though chemical inputs helped boost yields around the world, modern organic farming rose in reaction to worries about the impact of chemically intensive farming on the environment and human health. Organic agriculture gained traction in the 1970s as a result of growing knowledge of the detrimental environmental consequences of some industrial pesticides and fertilizers. According to United Nations Sustainable Development policies, numerous member states and other organizations have backed the Zero Hunger Challenge, which has been documented as it calls for (Food et al., 2012). Zero stunted children under the age of two, 100% access to adequate food all year round, All food systems are sustainable,100% increase in smallholder productivity and income, and Zero loss or waste of food. It is a fact that enhancing sustainable development through agriculture has been a trend and is reflected only through “organic” agriculture. Yet sustainable organic agriculture endures challenges and limitations as much as it has become a worldwide trend.

4.6. Sustainability in organic farming - trends

One of the most popular and rapidly expanding movements in sustainability is organic agriculture. The concept, sometimes known as regenerative farming, is at the heart of many emerging food and beverage sustainability initiatives. The program aims to reduce or eliminate synthetic fertilizers, boost agricultural production and yields, encourage biodiversity, preserve water, and trap carbon in the soil. It is often linked to organic farming practices (Pretty et al., 2018). The positive factors of organic farming attached to sustainable agricultural practices include the use of integrated pest management (IPM) plans to reduce pesticide consumption, Crop rotation, the planting of nitrogen-fixing ground coverings or cover crops, and/or the use of mulch can all help to improve soil health, use of no-till or reduced-tillage agricultural methods to decrease the soil compaction, using soil samples as a guide to determine the amounts of organic and synthetic fertilizer to be applied, promoting the use of organic fertilizers over synthetic fertilizers, avoiding the excessive use of synthetic fertilizers and promoting precision farming through the use of soil samples as a guide to determine the amounts of organic and synthetic fertilizer to be applied, promoting the use of organic fertilizers over synthetic fertilizers, and designing of new irrigation systems to maximize crop or pasture yield while reducing water wastage, erosion, and salinization (Baker et al., 2015; Tchaker et al., 2016; Chaichi et al., 2018; Salim et al., 2020; Merah et al., 2021). This also ensures the utilization of ground cover, and mulches, and limits pesticide usage, among other methods, to prevent soil erosion while highlighting biodiversity conservation. Organic farming is considered a flourishing sector with numerous health benefits and important environmental considerations. People are more concerned about organic products and are willing to pay a greater price for them due to potential health risks. Concern for the environment and a dedication to environmental sustainability also led to resource conservation and a favorable impact on organic purchasing.

4.7. Bibliometric analysis

The following Fig. 2 displays the data of Bibliometric analysis by retrieved data from the Web of Science Core Collection (WoSCC) database. We used the Web of Science Core Collection (WoSCC) database to aggregate publications from 1991 to 2022. Data were retrieved on June 6, 2022 at 1.30 p.m. of Coordinated Universal (UTC) time (acceded from the University of Tsukuba, Japan) articles were searched by using the term "sustainable agriculture*" in the "Title" field, and "articles" were filtered in the "document type" field, limited to articles only, and excluded all other documents. It was strictly limited to the articles published in English during the specified period (the selected period was 1991–2022). The retrieved data were analyzed using a quantitative analysis approach, knowledge mapping, and network analysis technique available at VOS viewer software (www.vosviewer.com). The study relied on the network strength of the author's linkage and the countries, keywords, and institutions.

As shown in Fig. 3, the bubble size of the keywords Agriculture and Sustainable Agriculture is almost the same. These two keywords show the highest number of occurrences, where the keyword Agriculture shows 43 times, and Sustainable Agriculture shows 42 times. The keywords Agriculture and Sustainable Agriculture form links with 40 other keywords in each cluster. The other keywords which have the subsequent highest frequency of occurrence are sustainability (34 times), climate change (33 times), and food security (33 times). Other keywords with many occurrences are biochar (28 times), Agrology (28 times), biodiversity (21 times), sustainable infestation (19 times), organic agriculture (18 times), organic farming (18 times), ecosystem services (18 times), conservation agriculture (17 times) and sustainable development (16 times). However, it was noted that less occurrence of some important keywords such as carbon sequestration (11 times), resilience (9 times), agroforestry (8 times), land use (6 times), soil degradation (5 times), deforestation (4 times) and carbon footprint (4 times).

Sustainable Agriculture had the most potent link strength among all author keywords and was highly connected to Biochar. The network strength displayed in Fig. 2 illustrates the relationship between the clusters. Climate change impact also shows a direct link to Sustainable Agriculture. Compared to other links, it displayed a relatively minor link strength, where a considerable gap is shown; therefore, it needs to expand the scope of sustainable Agriculture research involving climate change impacts. In this analysis, keywords such as "landscape" did not appear in the author's keywords network (Fig. 2). The term 'landscape' is associated with natural or cultural landscapes in the Sustainable Agriculture research fraternity. Again, a considerable gap between Sustainable Agriculture research involving "landscape" is related to natural and cultural domains. However, the keywords such as "Sustainability" and "organic farming " has a relationship with research trends.

5. Sustainability in organic farming - challenges & limitations

Even though organic farming is now a global trend in agriculture, challenges are limiting organic production. Organic producers confront

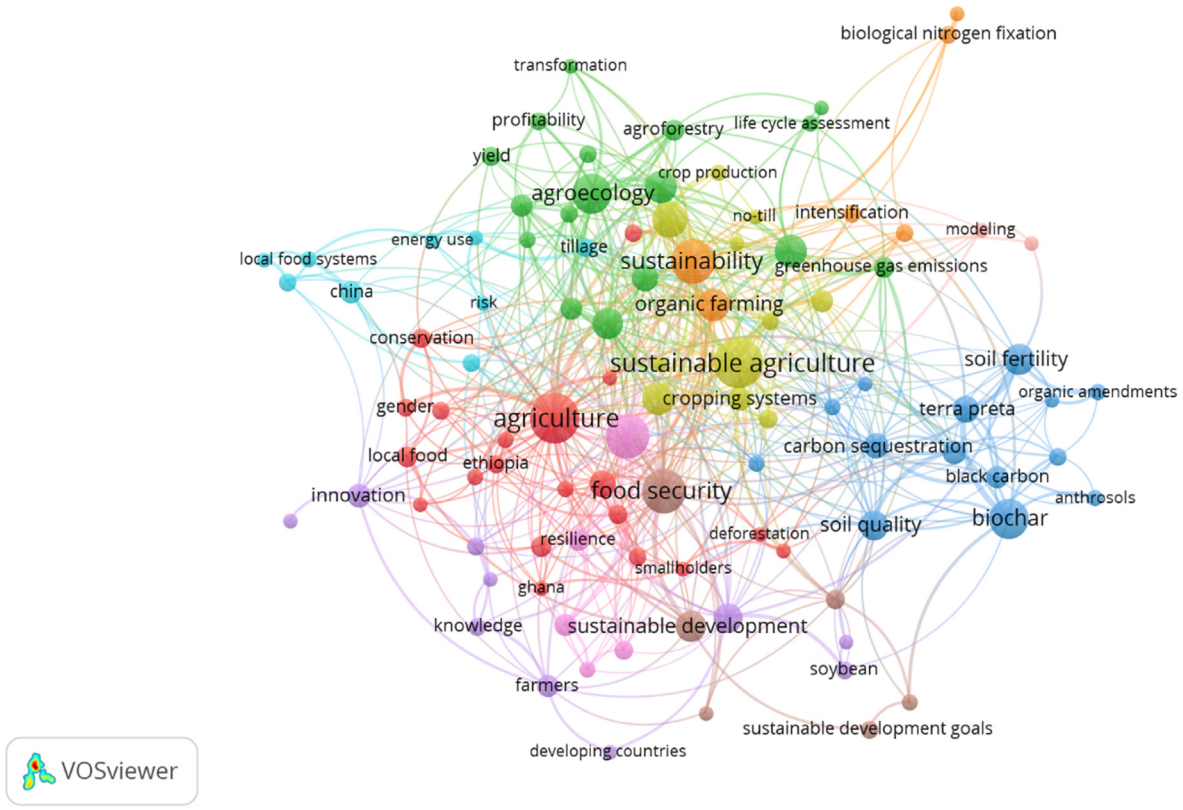

Fig. 3. Co-occurrence network (author keywords). Note: A threshold of 2 was applied for these 128 highly cited articles, resulting in 451 out of 2737 matching the criteria. The bubble size shows the total number of highly cited articles, line thickness, shows the linkage's strength, and the color shows the cluster. (For interpretation of the references to color in this figure legend, the reader is referred to the Web version of this article.)

distinct costs when compared to conventional farmers. Organic farmers spend less on purchased supplies than conventional farmers, but they pay significantly more for labor and feed (Durham and Mizik, 2021). Although organic products are frequently commended for their health and environmental benefits. Organic is surrounded by a lot of buzzes, and rightfully so. However, farming and producing organic food needs a significant amount of effort. There are numerous obstacles when it comes to Organic Farming. The fundamental difference between organic and conventional farming methods is that organic farming uses fewer chemicals in the food production process. Organic products, however, are more susceptible to deterioration for a variety of reasons, despite the obvious health benefits (Shennan et al., 2017). Organic products need to be consumed sooner to ensure food safety and appeal due to temperature variations during shipping and generally shorter shelf life. Time is one of the most significant issues in organic gardening. This isn't true in every case, but organic fruit and meats, in general, require getting to market faster. Another major issue in organic farming is pest infestations, which are as old as farming methodologies themselves. Pests such as rodents and insects can destroy crops if they are not controlled. As a result, people have been using pesticides to deal effectively with them for a long time. However, many chemicals are not allowed in organic farming because they are not of natural origin and are damaging the environment. In comparison to conventional farmers, organic farmers confront a distinct set of costs. Organic farmers spend less money on inputs, but their labor and feed costs are substantially greater. Organic farming also requires a lot of knowledge because it uses a systems approach to control fertility, weeds, and pests rather than relying on off-farm inputs. Organic farmers must also protect biodiversity, manage complex grazing systems, and keep animals healthy without using antibiotics. Despite excellent returns, organic grain production is lagging (Hoviet al., 2004).

5.1. Impacts on the environment due to current practices

5.1.1. Weeds, pests, and diseases related impacts

a) Weeds- Many weed species emerge in rice fields. In Sri Lanka, more than 70 grass species and dominant species vary according to locality factors, such as soil type, hydrology, and irrigation pattern, 10 to 20 species are considered economically important in rice fields, particularly, *Echinochola crusgalli*, *Ischeamum rugosum,* and *leptochloa chinensis.* In terms of the regional trend, Dry Zone is severely affected by weed infestation due to the limited amount of available water during the critical period. However, there is a high potential risk of breeding new invasive weeds with imported chemical fertilizers (Gunatilleke, 2008; Singh et al., 2014).

b) Pests Excess and inappropriate use of insecticide has disrupted the natural pest control mechanism which is achieved through the interaction of predators, pests, and parasitoids to sustain the balance of each population (El-Wakeil and Volkmar, 2013). Therefore, pest problem has become an important issue in rice fields and the breakdown of natural food chains/cycles, and loss of biodiversity of macrobian with loss of the active layer of soil can occur (Fahad et al., 2021).

The uncontrolled use of pesticides such as insecticides, herbicides and fungicides has become one of the most challenging issues when pursuing sustainable development. Intensively used pesticides threaten the environment, food safety, and human health. Pesticides are directly applied in soils and plants. An accidental release of pesticides may lead to their persistence in the environment for a long time. Proper management of pesticides prevents contamination of soil, water, and air (Özkara et al., 2015).

5.1.2. Water management

Both excess and deficit in water are major constraints on rice production in Sri Lanka(Warnakulasooriya and Shantha, 2021). Water runoff over the prepared soil layer may cause nutrition depletion, soil erosion, and desertification by lowering pH (Chaliseet al., 2019). This problem has become severe by inappropriate land management in recent years by blocking drainage ways or by the neglect of management by farmers (Wayne Skaggset al., 2012).

5.1.3. Soil fertility and nutrient

In addition to the low Nitrogen content, the micronutrient level of soil in Asian and African countries is at a critical threshold (Nazif and, Perveen, 2006; Sitanggang et al., 2006; Geremuet al., 2021). Zn, Cu Fe, and S are the most important micronutrient deficient in soil (Khurana et al., 2015; Shukla et al., 2018, 2021). Mixing of nitrate with groundwater and the quality of groundwater getting decreases (Brevik et al., 2020). Algal blooming, phosphate pollution (Eutrophication), and increasing cadmium due to phosphate fertilizer are bubbling issues (Gupta et al., 2007; Gamage, Basnayake et al., 2022).

5.1.4. Inferior management practices

Misuse of fertilizer and pesticides, often of excessive use, in the long term has caused environmental pollution downstream and contamination of water, and risk to human health (Biswas et al., 2014). Seed quality is often poor, and contaminated with weed seeds, hence magnifying the weed problem (Rubenstein et al., 2021).

5.1.5. Air & water pollution

Usage of mechanical equipment and instruments such as fossil fuel-used vehicles emit air pollutant gasses, and leakage of various types of oil, and lubricant products into soil and water are other major issues that are contributing to climate change (Chalvatzis, 2022). And also, the burning of organic parts of cultivation (mulch), agrochemical wrappings, and dumping of chemical containers into water bodies after usage causes air pollution, life-threatening for beings of water (Gonçalves et al., 2011; Gamage, Liyanapathiranage, et al., 2022).

5.2. Proper agricultural practices to minimize the impact

Concerning the improvement in farming practices of individual farmers and government support, several focus points are identified from the revealed major constraints; cultivars and timely cultivation, soil fertility improvement, weed, pests, and disease management, postharvest management, and extension services (Kariyasa and Dewi, 2011; Ngetich, 2012).

5.2.1. Cultivar and collective, timely cultivation

Traditional varieties of crop cultivation period were scheduled based on the change in season, with the onset of monsoon in the region; however, such timely cultivation has been gradually ignored with the use of short-duration cultivars. In addition, collective cultivation of rice with the same growth stage between rice fields has declined but is very important to reduce pest and disease occurrence. Usage and re-cultivation efforts of traditional old seeds, which are highly affordable for any climatic condition, diseases and pest attacks (Ranathunga et al., 2019).

5.2.2. Soil fertility improvement

Degradation of soil fertility by continuous cropping and runoff by intensive rain are common problems in many countries (Delang, 2018; Ferreira et al., 2022; Yu et al., 2022). For regeneration of fertility, Nitrogen addition with fertilizer may be recommended with caution to avoid excess use. Crop diversification is another method that has been promoted, for instance, the cultivation of chili, onion, green gram, cowpea, soybeans, ground nuts, and other vegetables in rice fields. Legume crops are particularly advantageous in that those plants help regenerate soil fertility. The addition of rice straws, and animal wastes to build up organic matter, would be practical at the farmers' level (Delang, 2018; Li et al., 2019; Yu et al., 2022). Occasional ploughing to 20–25 cm depth also helps nutrient accumulation and soil conservation (Huang and Zhao, 2017). Further usage of green manure, farm-yard manure (Cow dung), Surrogation, Organic liquid manure, vermitec, Guano, and Biochar are really important practices for sustainable agriculture (Gamage et al., 2022a; Gamage, Liyanapathiranage, et al., 2022b).

5.2.3. Weed, pest and disease management

Integrated Pest or Weed Management developed and implemented would be the most recommended strategy. This practice emphasizes the proper land preparation for prevention, minimum use of agrochemicals, and utilization of natural Biological Control mechanisms. Land preparation includes ploughing, peddling, and leveling to reduce the germination of weeds and management of off-field landscapes, such as bunds between fields which provide refuges for important natural enemies of insect pests during non-cropping seasons. The use of clean seeds without weeds contamination and appropriate water management is vital considerations for prevention. Usage of trap cropping, pest-repellent plants, traps, and bio-control agents are becoming most essential practices (Gianessi, 2013; Owen et al., 2015; Thiviya et al., 2022).

5.2.4. Attitude on agriculture and policy context

Encouraging people, awareness programs, and creating self-entrepreneurs through paddy/other products-related agricultural practices to decrease the scarcity of workforce attached agricultural sector, and reduce the unemployment count, including necessary government mediation on policy context too. Nurturing the young generation to think out of the box while bringing the exact uptake on the importance of investments in rice cultivation such as nutrition full, traditional healthy seeds productions targeting the export market, etc. (Kang et al., 2011; Sweileh, 2020).

5.2.5. Crop rotation

Crop rotation is a farming practice in which different crops mainly cruciferae, solanaceae, leguminosae, alliums, cucurbitaceae, and umbelliferae plant families are grown in the same field at different time periods (Mudgal, 2010; Yu et al., 2022). In this farming, practice avoid the families of vegetables that share similar pests and diseases as well as can suppress the growth of the weed. Rotating different plant families can assist in breaking the life cycle of many pests and diseases. Furthermore, crop rotation is helpful in many ways including soil fertility, food security, environmental development, and regeneration of rural life. It can effectively enhance climate resilience and reduce the fragility of agricultural cropping systems (Mudgal, 2010; Yu et al., 2022). Mix cropping, Inter Cropping, Cover Cropping, etc., are some more famous, useful agricultural practices for succeeding in organic farming (Delang, 2018; Li et al., 2019; Yu et al., 2022).

6. New innovation technologies to overcome limitations of organic fertilizers

Organic farming has become an essential tool when moving towards the future era to decrease the adverse effect of burning crops and global warming. Modern agricultural practices involve the use of chemical fertilizers and pesticides to meet the challenges of agriculture. Modern organic farming was developed as a response to the environmental harm caused by the use of chemical pesticides and synthetic fertilizers in modern agriculture, and it has numerous ecological benefits. A combination of organic fertilizer and new technologies is of utmost importance to reduce the limitations and challenges of organic fertilizer.

6.1. Sludge

Sludge is a semi-solid slurry that can be produced from a range of

industrial, water treatment, wastewater treatment, or on-site sanitation processes. Sludge also contains valuable organic matter and nutrients such as nitrogen and phosphorus and can therefore be very useful as an organic fertilizer or soil improver. Table 3 show several studies conducted on using wastewater treatment plant sludge as an organic fertilizer.

Table 3
Use of sludge and it's importance.

Uses of sludge	Importance	Reference
Organic mineral fertilizer	The sustainable production of locally available renewable resources and low-carbon impact nitrogen supply.	Chojnacka et al. (2023)
Sewage Sludge Soil Application	Some micronutrients and N were more efficiently supplied to maize plants by sewage sludge.	Corrêa et al. (2023)
Mineral fertilizer in maize crop	To help plants satisfy their N requirements, sewage sludge may be utilized to boost plant N reservoirs at silking, N translocation to grains, and post-silking N uptake.	Koutroubas et al. (2023)
Organo-mineral fertilizer based on olive waste sludge	Through direct and indirect mechanisms involving enhanced soil characteristics and increased P solubilization, organo-mineral fertilization is a viable method for enhancing the efficacy of low-P and high-P mineral fertilizers in alkaline soils.	Bouhia et al. (2022)
Sewage sludge as manure	N content - 2.0–3.5%, P_2O_5 content- 1.0–5.0%, K_2O content - 0.2–0.5%	Kumar et al. (2022a)
Phosphorus sources for organic agriculture	Recovered phosphorus can replace 43% of the requirement for commercial fertilizers according to a study in Germany	(Sichler et al., 2022)
Valuable agricultural products	It was more suited for use as fertilizer because the levels of phosphorus and nitrogen are high.	Banerjee et al. (2022)
Application of sludge on cropland	A sustainable management practice	(Seleiman et al., 2020)
Gamma-irradiated sludge as fertilizer	The material was of equal quality compared to the conventional fertilizer	Rathod et al. (2009)
Phosphate fertilizer from sewage sludge ash	It has been demonstrated that the plant uptake efficiency of zfertilizer generated from sewage sludge ash and regular phosphate zfertilizer is equal.	Franz (2008)
Sewage sludge ash as a phosphorus source for fertilizer production	It has been demonstrated that the plant uptake efficiency of fertilizer generated from sewage sludge ash and standard phosphate fertilizer is equal.	Herzel et al. (2016)
Oregano mineral fertilizer	Comparable crop yield response as conventional fertilizers	Kominko et al. (2017)
Sewage sludge as organic fertilizer	Enhance the economic yield of wheat and improve soil productivity	Khan et al. (2006)
Gamma Irradiated Sewage Sludge as Fertilizer in Radish	No discernible differences between fertilizer sources were found. The number of metallic micronutrients and heavy metals in the soil was below the US Environmental Protection Agency's (USEPA) recommended level, and even at greater application rates, no appreciable change was observed after two years.	Rathod et al. (2011)
sewage sludge for fertilizer	It is a promising solution for managing sewage sludge, allowing the WWTP in Zywiec to recycle 42–73 tonnes of nitrogen (N) and 82–140 tonnes of phosphorus (as P_2O_5) each year.	Kominko et al. (2019)

6.2. Biochar with organic fertilizer

Biochar is made from a variety of carbon-rich biomass namely Animal wastes, food wastes, sludge, industrial wastes, wood chips, agricultural wastes, and forestry wastes that have varying chemical and physical properties. Several technologies aid in the production of biochar like torrefaction, pyrolysis (slow, fast, and intermediate), hydrothermal carbonization, gasification, and flash carbonization. Pyrolysis is the most widely used technology in the processing of biochar from biomass (Kukreti et al., 2021). Organic fertilizer and biochar amendments have been used in agriculture to improve soil properties and enhance crop productivity. Zhang et al. (2020) reported that plant roots play an important role in the functions of plants. The addition of organic fertilizer and biochar reportedly afect roots, but it remains unclear how root morphology and physiology respond. Gamage et al. (2022a) revealed that anaerobically digested rice straw compost and rice husk biochar-coated urea significantly improve soil nutrients. In addition, biochar-fertilizer combinations (chemical or organic fertilizer) have a better performance than pure fertilizers, in terms of yield and plant nutrition. A combination of chemical fertilizers coated with biochar and organic fertilizer can potentially be used as a slow-releasing fertilizer. In addition, the chemical fertilizer coated with biochar contributes to mitigating the pollution of water bodies by inorganic fertilizers (Glaser et al., 2015; Agu et al., 2022; Gamage et al., 2022a). Fig. 4. Shows the benefts of organic manure combined with biochar amendments.

6.3. Biofertlizer

Biofertilizers are products containing one or more species of microorganisms that can mobilize nutritionally important elements from biological processes. These processes are biodegradation in soil, compost, nitrogen fixation, phosphate solubilization, and excretion of plant growth-promoting substances or cellulose in the environment. Biofertilizers are natural fertilizers that are living microbial inoculants of bacteria (Free-living nitrogen-fixing bacteria like Azotobacter, and Rhodospirillum), algae, and fungi alone or in combination with the availability of nutrients to plants. Decomposed organic materials, in combination with plant growth-promoting bacteria, are environmentally friendly and reduce chemical fertilizer use in crop production. Kumar et al. (2017) revealed that the application of bio-organic fertilizer improved soil organic carbon by 6–13%, along with an increased number of plant growth-promoting bacteria as compared with only using chemical fertilizer dose. In addition, bio-organic fertilizer can be considered a green technology to reduce 30% Chemical N and 100% TSP requirements in rice production. The role of biofertilizers in agriculture assumes reducing the cost of chemical fertilizers and their hazardous effects on soil health (Kumar et al., 2017). Mycorrhizae is a symbiotic association between a fungus and a plant and mycorrhizal biotechnology has a major component of sustainable organic farming (Varinderpal-Singh et al., 2020).

Vermicomposting is converted biodegradable waste into organic manure with the help of earthworms with no pile turning, no smell, and fast production of compost. The earthworms are bred in a mixture of animal wastes, soil, and agricultural wastes or decomposed leaf litter. The whole mass is converted into vermicompost, which can be used as an organic fertilizer on all types of plants. Zhou et al. (2023) reported the flexible application of different methods of earthworms, especially the contribution of earthworms and microbes to the composting process. The researchers' investigation showed that pathogenic genes, pathogenic microbes, and greenhouse gases have been significantly controlled and reduced. Furthermore, soil nutrition has been preserved and enriched. In addition, they mentioned that there are still many shortcomings and limitations in composting/vermicomposting technology in some cases, which is worthy of further research and discussion by the next researchers.

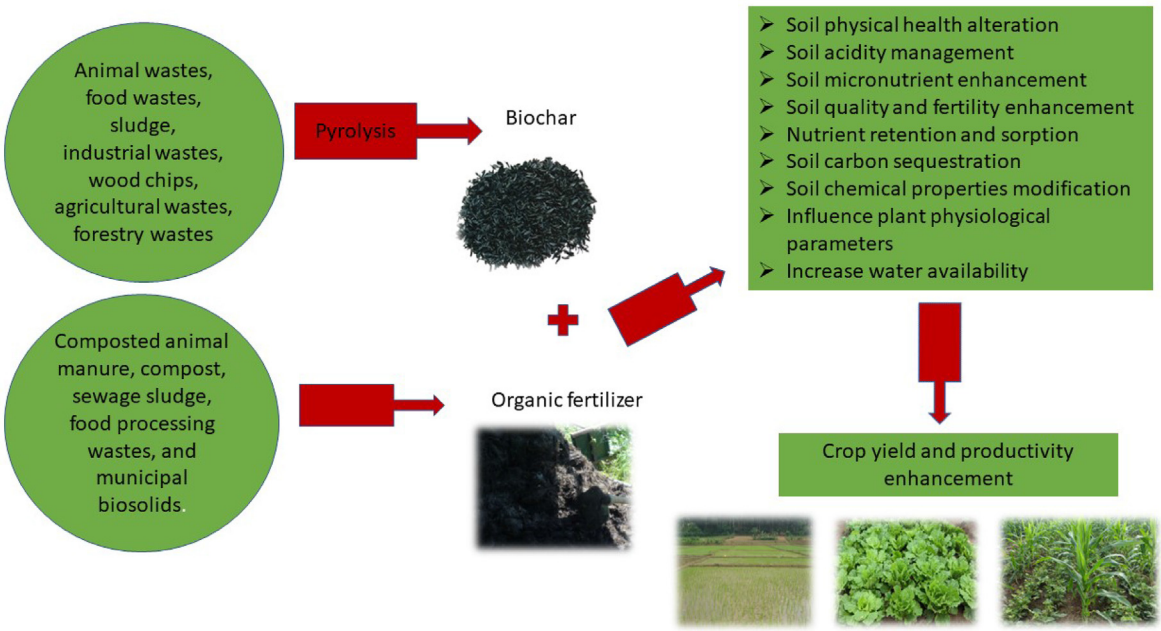

Fig. 4. Benefts of organic manure combined with biochar amendments.

6.4. *Organomineral fertilizers*

Organomineral fertilizers are a mixture of organic and mineral fractions and can be produced in several N, P, and K proportions suitable for crop requirements. The final product can be granulated, pelleted, or powdered form. Organomineral fertilizers enhance soil fertility. It improves soil physic-chemical properties and increases nutrient availability, water retention, and phosphate solubilization. In addition, organometal fertilizer enhances plant agro-physiological traits. It increases plant biomass and yield, improves nutrient assimilations, and improves plants physiological metabolism (Atere and Olayinka, 2012; Crusciol et al., 2020).

6.5. *Digital technology*

Digital technology and tools can help organic farmers to monitor and optimize crops and parm animal health, increase resource use efficiency, reduce environmental impact, and enhance farm profits. Digital technology can be used in organic farming including tillage, irrigation, fertilization, postharvest, storage, and transportation of farm products. Digital technology has the potential to eliminate poverty and food insecurity for the majority of smallholder farmers in the world. Advanced digital technology in agriculture is mostly used by large-scale farmers. They significantly contribute to sustainable agriculture. Although the existing digital services for smallholder farmers lack sustainability in organic farming, it is necessary to improve in the future and it will facilitate economic and environmental sustainability (Mushi et al., 2022).

7. Conclusions

To achieve the United Nations Sustainable Development Goals by 2030, agricultural methods must be altered. The best way to achieve the SDGs is a passionately debated topic. Based on research and arguments, Sustainable agriculture and food systems must supply sufficient and nutritious food for everyone while reducing negative environmental effects and allowing farmers to make a profitable living. It is agreeable that agriculture and food systems must change quickly and rapidly to achieve numerous SDGs while remaining within environmental constraints. However, the best way to accomplish this is fiercely discussed, with two chronicles dominating: incremental measures to improve efficiency in conventional agriculture while lowering negative externalities and agroecological-based ground-breaking restructuring of organic farming systems. A combination of organic farming and improved sludge, biochar with organic fertilizer, biofertilizers, organominerals and digital technology is of utmost importance to reduce the limitations and challenges of organic farming. The innovative and sustainable approach of organic farming enhances the agricultural productivity, and quality of life of many farmers in an environmentally friendly way.

Author contributions

Writing—original draft A.G, R.G., J.G., N.J., N.K., P.S., and O.M. Review, and editing, A.G, R.G., J.G., N.J., N.K., P.S., and O.M. All authors have read and agreed to the published version of the manuscript.

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Declaration of competing interest

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