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Review paper

Social and Ecological Impacts of Sustainable Agriculture

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Abstract

Background and Aim: Current industrial farming practices pose significant environmental and social challenges, including resource depletion, pollution, and unequal food access. Sustainable agriculture offers a solution by promoting ecologically and socially responsible farming methods. The aim of this study is to explore the principles and benefits of sustainable agriculture, focusing on its potential to enhance food security, reduce costs, and protect natural resources.

Method: This study employs a comprehensive review of sustainable agricultural practices, emphasizing their technical, social, and environmental aspects. It examines initiatives that prioritize safety, productivity, profitability, and low-input approaches while safeguarding human and animal health. Key areas of focus include soil preservation, sustainable nutrition methods, and practices that promote healthy food production while protecting terrestrial and aquatic ecosystems.

Results: Sustainable agriculture encompasses a range of innovative practices that prioritize soil health, efficient resource use, and environmental conservation. These methods aim to ensure high-quality food production, reduce costs through natural inputs, and minimize waste. By adopting sustainable agriculture, societies can work towards food security, improved nutrition, and a healthier environment.

Conclusion: Sustainable agriculture offers a promising path to address the challenges posed by conventional industrial farming. By embracing eco-friendly and socially responsible practices, we can protect natural resources, enhance food security, and promote healthier food production. This philosophy of sustainable agriculture encourages a harmonious coexistence with the environment, benefiting both current and future generations.

Keywords: *Sustainable agriculture, Ecology, Natural Resources, Society*

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Introduction

Sustainable Agriculture

Today, the use of modern methods in agricultural production in order to meet the increasing world population and related food and other vital needs brings sustainability problems to the forefront with decreasing environmental and natural resource values. Protecting our land heritage and environmental values in providing quantitative and qualitative production is among the complex challenges we face, and it also lays the foundation for the sustainable development of societies.

Intensive farming practices that have been used for more than half a century have had negative effects on the quality and health of agricultural soils. Today, advanced fertilization methods, plant nutrition and soil management, new biotechnological applications such as the use of bacteria and fungi to increase the efficiency of plant nutrient use are among the promising applications for maintaining soil life and productivity. Today, consumers all over the world have become sensitive to the quality of agricultural products, their effects on the environment during the production process, and the effects of products on human health. For this reason, it is important to evaluate the effects of new technologies and applications with a holistic approach for a sustainable agricultural production that protects soil fertility and the environment.

After the second half of the last century, there have been significant developments in agricultural production with new technologies, mechanization, increased use of chemicals and product-specific specialization. In many countries in the world, productivity in agricultural products has increased due to government policies that support increasing agricultural production and reducing food prices. Although these developments and changes have created many positive effects in production and reduced the risk of hunger, they also had significant negative effects on environmental values. Prominent among these are the loss of topsoil productivity, groundwater pollution, air pollution, greenhouse gas emissions, decline in small family businesses, neglect of living and working conditions of agricultural workers, new threats to human health due to the spread of new pathogens, food and water pollution, the concentration of agricultural industries and the disintegration of rural communities. The concept of "sustainable agriculture" has been introduced in recent years in order to offer innovative alternatives to these problems that arise on the environment and human life, and this concept is increasingly supported and accepted in agricultural production systems [1], [2], [3].

In this study, the interrelated effects of sustainable agricultural practices on agriculture, environment and social structure were evaluated.

Management of Natural Resources in Agriculture

Agricultural areas, healthy soils, water resources and plant genetic resources are essential inputs for food production, and the gradual decrease of these resources in our world necessitates their sustainable use and management. Increasing the productivity of existing farmland through sustainable farming practices, including the restoration of degraded lands, will also alleviate environmental pressures such as deforestation and opening new farmland for agricultural production. The use of improved irrigation and storage technologies in terms of effective use of water resources, the development of new drought-resistant crop varieties will contribute to the maintenance of productivity in arid areas [4].

Given the expected changes in temperatures, precipitation and pests associated with climate change, further investments in research, development and technologies are needed to improve the sustainability of food systems. Sustainable farming practices appear to be critical in increasing the resilience of local food systems, preventing future large-scale famines, and ensuring food security and adequate and healthy nutrition for all.

All lands, including agricultural lands, provide habitat for wildlife (flora and fauna), but their composition and quality are highly variable. Agricultural activities can have an impact on wildlife and habitats directly through the conversion of uncultivated natural habitats to vegetative production and indirectly due to the problems arising from the effects of high pollutant discharges from these habitats. OECD countries pay more attention to improving the habitat quality in agricultural lands, due to the significant value of areas with environmental and recreational value to the habitats of the society. Policy actions encourage endangered agricultural habitats and encourage producers to adopt agricultural management practices that are beneficial to habitat restoration [5].

The world's fresh and salt water resources are increasingly affected by global stressors that affect humans and aquatic ecosystems in complex ways. These stressors include invasive species and diseases spread by climate-induced increased seawater temperatures; dams and other barriers to fish migration; terrestrial origin domestic and industrial pollution effects play a dominant role. There are global agricultural environmental problems such as erosion, drought and floods caused by unfavorable land management such as deforestation, overgrazing, and water limitation in agricultural use. Overconsumption of at least 32% of the world's fish stocks threatens the health, economy and livelihoods of communities around the world. If species extinction causes an imbalance in the ecosystem, it is difficult for depleted stocks to return to sustainable levels, and other species dependent on depleted stocks may become unstable and cause more problems. In this respect, it is seen that the health of aquatic ecosystems is also related to terrestrial ecosystems and especially agricultural practices.

When agricultural production disrupts the natural resource base, the ability of future generations to produce and develop decreases, and it is known that many civilizations disappeared in ancient times for this reason. It is believed that from past civilizations in the Middle East, Mesopotamia, Mediterranean, Mesoamerica and ancient Central American civilizations were removed from there due to unsustainable agricultural and forestry practices and degradation of natural resources [6]. The sustainable agriculture approach aims to use natural resources in a renewable way and to minimize harmful effects on ecosystems outside of an agricultural production area. By designing biologically integrated farming systems based on the internal cycle of nutrients and energy, it is often possible to maintain an economically viable production system with less toxic intervention. Maintaining a high degree of genetic richness by preserving as many product varieties and animal breeds as possible in agricultural production provides the potential for more genetic resources for reproductive resistance against diseases and pests [6].

It is of great importance to protect soil resources and soil fertility, which are essential for agricultural production. Since the sustainability of agricultural production is possible with the existence of a healthy soil, it is of great importance to protect the soil quality and health.

Structure and Functioning of Agricultural Ecosystems

Research on different types of natural and human systems that have survived over time has shown that these systems are highly flexible, adaptable, and highly diverse. Resilience is an important criterion as many agro-ecosystems face conditions (climate, pest populations, etc.) that are often unpredictable and rarely stable over the long term. Since it is not always possible for an agricultural system to regain the exact form and function it had before it lost its function, it can organize itself and take a new form with adaptability and flexibility in changing conditions. Because the more diversity there is in product types or cultural knowledge within a food system, the more tools and ways a system must adapt to change [3].

Today, due to the high dependence of advanced plant species and varieties on chemical fertilizers,

the basic plant nutrients especially nitrogen and phosphorus have been disconnected from their natural cycle. It is estimated that the total phosphate reserves in the world for fertilizer production may be sufficient for only 50 to 100 years for food production [7]. Unless new reserves are discovered and innovations are developed in the recovery of phosphates from wastes, it is inevitable that the costs of crop production will increase. Recycling nitrogen and phosphorus from agricultural wastes, increasing the efficiency of fertilizer applications and using organic fertilizers are important elements of sustainable agriculture. Recycling of nutrients is easier in agricultural enterprises where plant and animal production are carried out together. Therefore, comprehensive mixed crop-animal production systems, especially in developing countries, can significantly contribute to future agricultural sustainability and global food security.

Due to the shrinkage in water resources due to global warming and the increasing demand in plant production, water shortages are experienced in agricultural production in many regions of the world. In addition, deterioration in the quality of water resources threatens soil quality in medium and long-term crop production. Today, irrigation water salinization, agricultural nutrient overloads, the introduction of industrial emissions and pesticide contamination are common water quality problems. Selection and breeding of more drought- and salt-tolerant crop species and more resistant animal breeds in sustainable agro-ecosystems, the use of low-volume and efficient irrigation systems, and appropriate management of soils and crops to reduce water loss are among the ways to use water more efficiently.

Modern agricultural practices are highly dependent on non-renewable energy resources, especially oil, and the continuous use of these resources is not possible in the long term. The aim in sustainable agriculture should be to reduce external energy input and replace non-renewable energy sources with renewable sources (e.g. solar and wind energy, biofuels from agricultural wastes, or animal or human labor where economically feasible) [6].

Sustainable Agriculture Practices and Current Methods

Sustainable agriculture is a controversial term and not a single, well-defined end goal. The scientific understanding that constitutes environmental, social and economic sustainability is constantly evolving and is influenced by contemporary issues, perspectives and values. For example, while the issue of climate change was not considered as a critical issue in agriculture 20 years ago, it is seen as the cause of many problems today. The details of what constitutes a sustainable system can vary from one set of conditions (for example, soil types, climate, labor costs) to another and from one cultural and ideological perspective to another. Farmers apply methods that are meaningful to them and reflect their values as a way of life. In this sense, a wide variety of tools and options can be used in practice depending on the conditions [8], [9].

Agroforestry

In forest systems, which have many ecological layers, carbon is stored and natural material cycles work more healthily. Agroforestry is the integration of trees and shrubs into agricultural production systems to provide environmental, economic and social benefits. Agroforestry is based on growing crops among the empty spaces of mature forest trees or natural vegetation. In this production system, some fruits, vegetables, grains, flowers, herbs, bioenergy raw materials and other plants can be designed for production in areas where the land and vegetation are suitable [10]. Agroforestry is an important alternative practice that can increase agricultural production and income, especially for small farmers and rural people. Agroforestry systems are also multifunctional production systems that can provide a wide range of economic, sociocultural and environmental benefits [11].

Integrated Pest Management and Mechanical Weed Control

It includes a careful evaluation of all available pest control techniques to keep unwanted pests out of their crops, followed by appropriate measures to prevent the development of pest populations. Biological, chemical, physical and crop-specific (cultural) management strategies and practices are managed in an integrated manner to grow healthy crops and minimize pesticide use [12]. Weeds are undesirable plants that play a very important role in different ecosystems, but reduce crop yields by causing water and nutrient loss in the soil in agricultural production. The use of herbicides, while providing effective weed control, causes ecological imbalance in terms of the environment and causes significant damage to soil biological activity and productivity. Increasing crop yield by eliminating unwanted plants in crop production is seen as an ecological and sustainable weed management, using manual or various hand tools and soil cultivation tools in agricultural enterprises.

Aquaponics

It is a production model in which fish production is integrated into hydroponic farming practices. In soilless agriculture, while the nutrient solution circulates in the system to feed the vegetable plants, an important income is provided by maximizing the available space and energy use by raising fish in these nutrient pools at the same time. The wastes of fish grown in the Aquaponics system are mineralized by nitrifying bacteria and converted into plant nutrients. These nutrients are consumed by the plants in the system, filtering and cleaning the water so that the fish can live, and a healthy environment is provided for both the fish and the plants grown [13].

Erosion Control and Cultivation of Cover Crops

Terracing from natural materials, growing cover crops such as rye, clover, oats, buckwheat and mustard grass, grazing management and prevention of deforestation are among the general solutions used to prevent soil erosion. Cultivation of cover crops prevents soil erosion and prevents macro-soil organisms such as earthworms from frost death in winter. Cover crops help reduce soil erosion by increasing surface residue. They increase the effectiveness of applied fertilizers by improving the structure and water holding capacity of the soil [14].

Optimum Water Management

Water is an important natural resource for the life of living things and the existence of human civilization. Today, efficient and sustainable use of water resources has become one of the main challenges [15]. Rational use of fertilizers and pesticides in crop production will greatly reduce the entry of emissions from agricultural areas into surface and ground waters. Low-volume and target-effective drip irrigation method provides an economical water use in irrigation.

Use of Heirloom

Heirloom (old seeds) are examples of open-pollinated plant varieties that are preserved and transmitted through generations and community sharing. In plant production, heirloom have been bred from past to present to provide more yield, biomass and quality characteristics suitable for consumer demands. However, in this breeding process, reductions in genetic diversity of newly developed products and reduction in their environmental adaptation abilities have been observed which reduces economic production options and threatens agricultural sustainability. In addition to different taste and quality characteristics, heirloom generally have genes that are more capable against diseases and environmental changes that may be important in the future, and have an important role in providing biodiversity and food flexibility [16].

Integration of Plant and Animal Production

An economic, effective and sustainable natural matter cycle is realized by the farmers' management of plant and animal production together, growing cover crops for the feeding of farm

animals, and using animal wastes on the soil as organic fertilizer. Integrated crop/livestock farming improves soil quality, increases crop production productivity and land use efficiency [17].

Regenerative Grazing Management

In livestock grazing, limiting animals' access to land will reduce the damage animals do to their grazing land. The goal of regenerative grazing (for example, time-controlled grazing) is to manage the destruction caused by animal grazing by rebuilding biodiversity by maximizing water, nutrient cycling and energy efficiency in the local ecosystem. Regenerative rotational grazing provides higher grass production and carbon storage [18].

Permaculture

Permaculture, which is used to mean "Permanent Agriculture" and is generally seen as a set of horticultural techniques, has turned into a design philosophy today. Permaculture is a practical method of developing ecologically compatible, efficient and productive systems that can be used in all living spaces and is recognized as an innovative framework for creating sustainable lifestyles [19].

Polyculture Agriculture

Polyculture is the cultivation of two or more compatible agricultural plants together. Much like permaculture, polyculture farming is a way of growing sustainable food that replicates the natural ecosystem. In polyculture agriculture, various different plants are grown on the same piece of land on a much smaller scale. Polyculture applications provide benefits such as using a single piece of land for more than one crop, increase in biological diversity, decrease in diseases and pests, increase in soil fertility, use of less energy and synthetic fertilizers, and more efficient use of natural resources [20].

Reduced Tillage

Reduced tillage means less work intensity in the field or on the farm, shallower tillage depth. Intensive and repeated tillage has a detrimental effect on long-term soil physical properties and health. Structural deterioration of the soil is reduced through reduced tillage or no-till farming and crop residues and soil protection are provided. Crop rotations, cover crops and reduced tillage practices together with organic matter applications to the soil make the fertility of agricultural soils sustainable. It is anticipated that reduced tillage has beneficial effects on soil physical and chemical properties and the practice can replace traditional farming systems [21].

Crop Rotation and Diversity

Rotating crops or changing the type of crop grown in the same location is an effective method of controlling pests and weeds and helps maintain soil health. With crop rotations, soil fertility increases and soil structure is preserved, especially when legumes are used in rotation. In addition, pest cycles are disrupted and weeds are suppressed and the plant helps in the fight against diseases and pests [22].

Urban Agriculture

This practice can be in the form of crop cultivation in urban areas, backyard, roof and balcony gardening, community gardening in vacant lots and parks, urban environment agriculture by the roadside, animal grazing in the open field, and aquaculture facilities in an intensive indoor hydroponic farming environment. Urban agriculture facilitates access to food, reconnects communities to the practice of growing food, and unifies society at various levels. Urban agriculture contributes to a more conscious urban consumer profile of how crops are grown and what grows regionally and seasonally [23].

Use of Renewable Energy Sources

The concept of sustainable agriculture is based on the balance of minimizing the use of limited

natural resources and harmful environmental impacts, maximizing crop productivity and maintaining economic stability. There is a need to encourage the use of renewable energy systems such as solar photovoltaic water pumps and electricity, greenhouse technologies, solar dryers for post-harvest processing and solar hot water heaters in reducing energy costs in agricultural enterprises [24]. Energy costs in agricultural enterprises can be reduced by energy saving measures and the use of wind, solar, biomass and other renewable resources, and additional income is provided for farmers and rural businesses.

Social Impacts in Sustainable Agriculture

The United Nations Sustainable Development Goals include "Ending hunger, ensuring food security and improved nutrition and promoting sustainable agriculture". In order to achieve this, it is stated that there are mutual connections in supporting sustainable agriculture, empowering small farmers, promoting gender equality, ending rural poverty, ensuring healthy lifestyles and combating climate [25].

It is predicted that agricultural systems around the world will become more productive and less wasteful, that sustainable agricultural practices and food systems, including both production and consumption, can be managed with a holistic and integrated view, and a conscious transformation in the farmer and managerial communities. Agricultural sustainability is based on the principle of meeting the needs of the present without compromising the ability of future generations to meet their own needs. Therefore, long-term sustainable management of natural and human resources requires good planning. The management of land and natural resources includes maintaining or improving the quality of these resources and reusing them for the future. The management of human resources also includes considering social responsibilities such as the working and living conditions of both present and future producers, the needs of rural communities, and consumer health and safety [26].

The sustainability of agricultural ecosystems depends on the knowledge, technical competence and skilled human workforce required to manage them effectively. Given the ever-changing and indigenous nature of agriculture, agricultural sustainability requires a diverse and adaptable knowledge base that uses both empirical science and farmers' own local knowledge. Social institutions that support the education of both farmers and scientists and foster innovation and farmer-research partnerships are key to agricultural productivity as well as long-term sustainability [6].

Agricultural ecosystems and food systems form the components of sustainable agriculture. Agricultural ecosystems are envisioned in the broadest sense, from individual areas to farms and ecoregions, while food systems including distribution and food consumption components similarly range from small family businesses to the local community and global population. When evaluated in terms of the system, the capacity of agricultural production and distribution enterprises to affect human communities and the natural environment is better understood and there is a need to evaluate technical and social factors in integrity in planning.

Conclusion

Social, economic and environmental sustainability are closely interrelated and are essential components for a sustainable agriculture. Inefficiency, cost increases and impoverishment in the agricultural sector force producers to neglect natural resources such as soil, water and environment in order to earn their livelihood, and these problems are increasing day by day. Monoculture agricultural practices and intensively used agricultural chemicals, which have been applied in many countries of the world for about 70 years, have caused serious cost increases in agricultural

production, infertility of soils, pollution of food and environment, and deterioration of ecological balances in nature. Sustainable agricultural practices are seen as an economic, social and environmentally friendly production model that ensures the rational use of the decreasing natural material resources in the world for agricultural production, the healthy functioning of natural material cycles, productivity and self-sufficiency in agricultural enterprises. In this production model, societies can adapt and develop sustainable agricultural systems by creating policies that integrate social, environmental and economic interests according to regional conditions. However, an important local knowledge and effective training support for producers, a holistic planning and coordination are required for the adoption and dissemination of the sustainable agriculture model.

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Conflict of interests

The authors declare that there are no competing interests.

Reference

[1]. Pimentel D, Hepperly P, Hanson J, Douds D, Seidel R. Environmental, energetic, and economic comparisons of organic and conventional farming systems. Bioscience 55. 2005:573e582.
[2]. FAO (Food and Agriculture Organization of the United Nations). Special: Biodiversity for Food and Agriculture: Farm Animal Genetic Resources. 1998; FAO: Rome.
[3]. Gliessman SR. Agroecology: ecological processes in sustainable agriculture. Boca Raton, FL: CRC press; 2000.
[4]. Dubois O. The state of the world's land and water resources for food and agriculture: managing systems at risk. Earthscan; 2011.
[5]. OECD. Wildlife habitats, 2023. https://www.oecd.org/greengrowth/sustainable-agriculture/themewildlifehabitats.htm
[6]. Brodt S, Six J, Feenstra G, Ingels C, Campbell D. Sustainable agriculture. Nature Education Knowledge. 2011;3(10):1.
[7]. Steen I. Phosphorus availability in the 21st century: management of a non-renewable resource. Phosphorus & Potassium. 1998;217:25-31.
[8]. Altieri, M. A. Agroecology: The Science of Sustainable Agriculture. Boulder, CO: Westview Press. 1995.
[9]. Kim H. Why sustainable farming is more important now than ever. 2021. https://sentientmedia.org/sustainable-farming/.
[10]. Mosquera-Losada MR, Prabhu R. Agroforestry for sustainable agriculture. Burleigh Dodds Science Publishing Limited; 2019.
[11]. FAO. Agroforestry. 2023; https://www.fao.org/forestry/agroforestry/80338/en/.
[12]. World Health Organization. Managing pesticides in agriculture and public health: a compendium of FAO and WHO guidelines and other resources. World Health Organization; 2021.
[13]. Kyaw TY, Ng AK. Smart aquaponics system for urban farming. Energy procedia. 2017;143:342-7.
[14]. Lu YC, Watkins KB, TEASDALE JR, ABDUL-BAKI AA. Cover crops in sustainable food

production. Food Reviews International. 2000;16(2):121-57.
[15]. Samian M, Mahdei KN, Saadi H, Movahedi R. Identifying factors affecting optimal management of agricultural water. Journal of the Saudi Society of Agricultural Sciences. 2015;14(1):11-8.
[16]. Dwivedi S, Goldman I, Ortiz R. Pursuing the potential of heirloom cultivars to improve adaptation, nutritional and culinary features in a changing climate. Preprints 2019; 2019060022
[17]. Hilimire K. Integrated crop/livestock agriculture in the United States: A review. Journal of Sustainable Agriculture. 2011;35(4):376-93.
[18]. de Otálora XD, Epelde L, Arranz J, Garbisu C, Ruiz R, Mandaluniz N. Regenerative rotational grazing management of dairy sheep increases springtime grass production and topsoil carbon storage. Ecological Indicators. 2021;125:107484.
[19]. Bhandari D, Bista B. Permaculture: A key driver for sustainable agriculture in Nepal. International Journal of Applied Sciences and Biotechnology. 2019;7(2):167-73.
[20]. Adamczewska-Sowińska K, Sowiński J. Polyculture management: A crucial system for sustainable agriculture development. Soil Health Restoration and Management. 2020:279-319.
[21]. Tebrügge F, Düring RA. Reducing tillage intensity—a review of results from a long-term study in Germany. Soil and tillage research. 1999;53(1):15-28.
[22]. Smith RG, Gross KL, Robertson GP. Effects of crop diversity on agroecosystem function: crop yield response. Ecosystems. 2008;11:355-66.
[23]. FAO Director-General calls for transformational change in the way we manage our forests and food systems that depend on them. 2020; http://www.fao.org/news/story/en/item/1311477/icode
[24]. Chel A, Kaushik G. Renewable energy for sustainable agriculture. Agronomy for sustainable development. 2011;31:91-118.
[25]. United Nations Sustainable Development Goals, Goal 2 Zero hunger. 2021; https://www.un.org/sustainabledevelopment/hunger/
[26]. Hinrichs CC, Lyson TA, editors. Remaking the North American food system: Strategies for sustainability. Lincoln, NE: University of Nebraska Press; 2008.