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Sustainable Agriculture

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***Abstract*:- The United Nations has estimated that there will be roughly 10 billion people on earth by the year 2050. Feeding these people has been a major global challenge. The fear that global demand for food will outstrip supply has led to a significant debate. Although farmers have used different means in the past to increase the size of their production, the means that they have used to achieve the growth have reached their limits. Future agriculture will require using new approaches aimed at increasing both productivity**
and environmental protection. It has been realized that sustainable agriculture is the most realistic way to feed the rapid increasing global population. Sustainable agriculture is one that produces abundant food while protecting the environment and maintaining soil fertility. This paper provides an introduction to sustainable agriculture.

Key Words: Sustainable agriculture, sustainable farming, environment, technology

INTRODUCTION

Every person on earth needs food every day. Modern technology and services have improved the production of food. Agriculture is the largest industry on the planet and it
Includes crop, horticulture, animal husbandry, forestry, and fisheries. It provides jobs for a significant part of the world population.

The world is undergoing changes that will shape the livelihood of millions of people in the coming years. The world's population is expected to grow to about 10 billion by 2050. Meetings the rapidly increasing global food demand with existing farming agricultural practices is likely going to lead to more intense competition for natural resources and land degradation.

Traditional agriculture practices have caused massive deforestation, water scarcities, and soil depletion. It cannot deliver sustainable food and agricultural production. Expanding food production and economic growth using traditional practices have often come at a heavy cost to the natural environment. Therefore, "business-as-usual' is not an
option [1].

Sustainability has recently become popular in education, research, and government.
There are three popular definitions of sustainability: sustainability as food sufficiency; sustainability as stewardship; and sustainability as community [2]. Also, the following items are regarded as the three pillar of sustainability [3]:

- *Profit* over the long term. It uses state-of-the-art, science-based practices that maximize productivity and profit while minimizing environmental damage. Profits exceed the profitability of the conventional system.
- *Stewardship* of our nation's land, air and water. Environmental sustainability in agriculture means good stewardship of the natural systems and resources that farms rely on.
- *Quality of life* for farmers, ranchers, and their communities. Farmer workers should be given the opportunity to form, join a labor union without fear of reprisal, intimidation, or harassment.

The International Institute for Sustainable Development contributes to sustainable development through policy recommendations on economic policy, climate change, natural resources management, and international trade.

THREATS TO AGRICULTURE

Farmers face major risks, including extreme weather, long-term climate change, and price volatility in input and product markets, climate change, resource scarcity, and changing consumption patterns. A number of global trends are influencing food security and the overall sustainability of agricultural systems. These include:

- Rapid, global urbanization is accelerating the dietary transition
- Population growth will boost demand for food
- Ageing accelerating among rural populations
- The world's farmland is becoming increasingly unsuitable for production
- Climate change will affect every aspect of food production

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- Consumers waste 30-40 percent of all food
- Persistent poverty, inequality, and food insecurity
- Hunger is a major problem, particularly in developing countries
- Diverse trends in economic growth, family incomes, agricultural investment, and economic inequality
- Greatly increased competition for natural resources
- Plateauing of agricultural productivity for many crops and animals
- Increased conflicts, crises, and natural disasters
- Structural changes in economic systems and employment implications
- Advanced food production systems and resulting impacts on farmers' livelihoods
- Changes in international financing for sustainable development
- Increasing human demands for food, water, energy, and land has led to a new phenomenon of "land-grabbing."

These issues pose a challenge and are the product of poor foresight and planning. They clearly indicate that agriculture needs innovation, the challenges of tomorrow cannot be resolved with yesterday's methods. We need ways to feed the world population in a sustainable way and in keeping with human dignity. The preservation and sustainable utilization of resources is of vital importance for the interest of all mankind and our environment. Agriculture is at the heart of the sustainability challenge. Interest in sustainable agriculture possibly had its roots in the notion of sustainable development, which is based on intergenerational obligation and equity.

WHAT IS SUSTAINABLE AGRICULTURE?

Agriculture is one of the biggest threats to a healthy environment. Sustainable agriculture refers to farming that is good for the environment, animals, and people. It is agriculture without depleting the earth's resources or polluting its environment. It may also be regarded as farming in sustainable ways without compromising the ability for current or future generations to meet their needs. It involves farming predicated on the spiritual and practical notions and ethical dimensions of responsible stewardship and sustainable production of wholesome food. It provides a potential solution to enable agricultural systems to feed a growing population without negative effect on the environment and human population. It includes promoting urban farming, which favors equitable access to resources, managed in the most efficient way. A typical example of unsustainable agriculture is the application of fertilizer or manure, which can improve the productivity of a farm but can pollute the environment. An example of growing food in a relatively sustainable way is the practice of growing food in the backyard of houses, schools, etc. [4].

The idea of sustainable agriculture came out of fear and anxiety that the planet's carrying capacity, in terms of the ability to feed humanity, has been reached or even exceeded and the food demand of the rapidly increasing global population cannot be met.

It has become an important topic in international policy due to its potential to reduce environmental risks. The goal of sustainable agriculture is to reduce environmental degradation due to farming. Implementation of sustainable practices in agriculture comes through the adoption environmentally-focused technology.

As illustrated in Figure 1, sustainable agriculture has environmental, social, and economic dimensions considered together [5]. Sustainability demands that practices be economically viable, environmentally safe, and socially acceptable. Environmental sustainability promotes agricultural practices that are less dependent on fossil fuels and minimizes their impact on climate change. Social sustainability embraces the capacity of a system to continue to meet society's expectations for social justice and security, including intergenerational equity. Economic sustainability is the capacity for a system to continuously provide goods and services whose values exceed the cost of production [6].

The major characteristics of sustainable agriculture include the following [7]:

- *Conservation and preservation:* What is taken out of the environment is put back in, so that land and resources such as water, soil and air can be replenished and are available to future generations.
- *Biodiversity:* Farms raise different types of plants and animals, which are rotated around the fields to enrich the soil and help prevent disease and pest outbreaks. Figure 2 shows cattle in a biodiverse environment [8].
- *Animal welfare:* Animals are treated humanely and with respect, and are well cared for. They are permitted to carry out their natural behaviors, such as grazing, rooting or pecking.
- *Economically viable:* Farmers are paid a fair wage and are not dependent on subsidies from the government. Sustainable farmers help strengthen rural communities.
- *Social justice:* Workers are treated fairly and paid competitive wages and benefits. They work in a safe environment and are offered proper living conditions and food.

FACTORS AFFECTING SUSTAINABLE AGRICULTURE

The most important factors for a farming site are climate, soil, nutrients and water resources. These factors must be taken into account when addressing sustainable agriculture that can ensure food security for all.

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- *Climate Change:* Changing climatic conditions impact yields in a number of different ways depending on crop and location. For example, rising temperatures can cause faster crop development. However, extreme temperatures can damage plant cells and lead to catastrophic losses. Future crop yield changes under climate change [9]. Climate often compells farmers to adapt their agricultural practices. Figure 3 shows climate change in America [10].
- *Land Areas:* Data on land cover is used to estimate the amount of suitable land available for future farming. Not all regions are suitable for agriculture. Only a small portion of the earth's surface is arable land. Irrigation, plays an important role in enhancing productivity and minimizing the impacts of extreme climate conditions on crop production. Some argue that land reform is an essential step towards reducing social inequalities within the food system. While smallholder farmers in emerging economies may have an opportunity to increase their farm size, farms will remain small in many parts of the developing world [11]. Lands protected by conservation easements provide additional public benefits, including environmental quality and protection of open space.
- *Technology:* Technological advances has introduced radical changes to the agricultural working environment in recent years. For example. Smart farming, based on the incorporation of information and communication technologies (ICT) into agricultural production systems, allows a large volume of data to be generated [12]. New technologies are changing the way stakeholders, and government think about the agriculture industry, with the hope for solving the hunger and food scarcity problem. Although technology is certainly part of the solution, it alone cannot solve the global crisis. Some technologies are still expensive to most farmers, especially for the smaller ones and those in developing nations.

CAMPAIGN FOR SUSTAINABLE AGRICULTURE

Sustainable agriculture requires new approaches to using natural resources and systems. The following areas of consensus have emerged as the key paths of action [13]

1. Organized small and medium farmers, fully including women farmers, should be a primary focus of investment – recognizing that private enterprise will play a significant role in many solutions
2. Define the goal in terms of human nutrition rather than simply "more production"
3. Pursue high yields within a healthy ecology – they are not mutually exclusive and policy and research must reflect that
4. Impel innovation and the availability of diverse technologies suitable in different socioeconomic and ecological contexts
5. Significantly reduce waste along the entire food chain
6. Avoid diverting food crops and productive land for biofuels, but explore decentralized biofuel systems to promote energy and livelihood security that also diversify and restore rural landscapes
7. Insist on intelligent and transparent measurement of results - we cannot manage what we cannot measure
8. Develop and adapt public and private institutions that can effectively respond to these new goals
9. Motivate and reward investments and business systems that result in measurable impacts to the "public good."
10. Strengthen international and national governance for sustainable resource use, with particular emphasis on the capacity of developing countries to participate
11. Establish accountability mechanisms for damage to the environment and/or human rights violations and to provide remedies for those rights that are violated.
12. Produce crops with high yield and nutritional quality to meet existing and future needs, while keeping resource inputs as low as possible.
13. Ensure that any adverse effects on soil fertility, water and air quality, and biodiversity from agricultural activities are minimized, and positive contributions are made where possible.
14. Optimize the use of renewable resources while minimizing the use of non-renewable resources.

BENEFITS

Sustainable intensification has become a priority for the United Nations. Sustainable agriculture involves using farming techniques that are economically viable, protect
the water resources from pollution, treat livestock animals humanely, and maintain soil
fertility for future generation.

The benefits of sustainable agriculture can be divided into human health benefits and environmental benefits [14]. In terms of human health, crops grown through sustainable agriculture are better for people due to the lack of chemical pesticides and fertilizers. The crops produced through sustainable agriculture can also be more nutritious because the overall crops are healthier and more natural. Sustainable practices lend themselves to smaller, family-scale farms. These farms often find their best niches in local markets, within local food systems, often selling directly to consumers. Sustainable agriculture could be a way to achieve food sovereignty, it could also be a solution to hunger and food security.

Sustainable agriculture has also had positive impacts of the environment. The reduced reliance on fossil fuels results in the release of less chemicals and pollution into the environment. Sustainable agriculture also benefits the environment by maintaining soil quality, reducing soil degradation and erosion, and saving water. It attempts to minimize the harmful effects on the environment from pollution, wind and water erosion, and other types of environmental damage arising from agricultural production. Figure 4 depicts some of the benefits of sustainable agriculture [15].

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CHALLENGES

The challenges facing agriculture over the coming decades are many and complex.

While significant progress has been made towards achieving the sustainable development goals, critical environmental, social, economic and institutional challenges are still to be overcome. Two crucial connected challenges are [16]: (1) the persistently high levels of hunger and malnutrition – particularly in the rural areas of many developing countries – only slowly declining rates of poverty; and (2) an unsustainable and increasing burden of human activities on the earth's carrying capacity. Some researchers affirm that food insecurity, hunger and poverty are not technical issues caused by insufficient food production, but rather political issues related to uneven distribution.

CONCLUSION

Agriculture is essential to international development, Sustainable agriculture is a kind of agriculture that focuses on producing long-term crops and livestock while having minimal effects on the environment. It an agricultural production that is economically viable and does not degrade the environment over the long run. Proper protection, management, and governance of the environment are therefore crucial to sustainable

agriculture. More information about sustainable agriculture can be found in the books in [17-23] and the following related journals: *The Journey to Sustainability Begins With Education and* Sustainability, *American Journal of Alternative Agriculture*

REFERENCES

[1] FAO, The *future of food and agriculture: Trends and challenges.* Rome, Food and Agriculture Organization of the United Nations. 2017.
[2] "Sustainable agriculture," *Wikipedia*, the free encyclopedia https://en.wikipedia.org/wiki/Sustainable_agriculture
[3] R. Lowrance, P. F. Hendrix, and E. P. Odum, "A hierarchical approach to sustainable agriculture," *American Journal of Alternative Agriculture*, November 2009.
[4] "What is sustainable agriculture?" Sustainable Agriculture Research and Education (SARE), https://www.sare.org/resources/what-is-sustainable-agriculture/
[5] "A short guide to sustainable agriculture," https://sustainablefoodlab.org/a-short-guide-to-sustainable-agriculture/
[6] G. P. Robertson, "A sustainable agriculture?" *Dædalus, the Journal of the American Academy of Arts & Sciences*, vol.144, no. 4, Fall 2015, pp.76-89.
[7] "What is sustainable agriculture?" https://www.cbf.org/join-us/more-things-you-can-do/buy-fresh-buy-local/what-is-sustainable-agriculture.html
[8] "Sustainable agriculture: A short report by compassion in world farming 2008," https://www.ciwf.org.uk/media/3817786/sustainable-agriculture-report.pdf
[9] FAO, The *future of food and agriculture: Alternative pathways to 2050.* Rome, Food and Agriculture Organization of the United Nations. 2018.
[10] S. Mufson et al., "2°C: beyond the limit: Extreme climate change has arrived in America," https://www.washingtonpost.com/graphics/2019/national/climate-environment/climate-change-america/
[11] Oxfam, "the future of agriculture: synthesis of an online debate," July 2013, https://oi-files-d8-prod.s3.eu-west-2.amazonaws.com/s3fs-public/file_attachments/dp-future-of-agriculture-synthesis-300713-en_0_0.pdf
[12] A. Trivedi1 and N. Nandeha, "Smart farming: The future of agriculture," *Agriculture & Food: E-Newsletter*, October 2020.
[13] D. Giovannucci et al., "Food and Agriculture: the future of sustainability," United Nations Department of Economic and Social Affairs Division for Sustainable Development, March 2012, https://sustainabledevelopment.un.org/content/documents/1443sd21brief.pdf
[14] "What is sustainable agriculture?" https://study.com/academy/lesson/what-is-sustainable-agriculture-definition-benefits-and-issues.html
[15] "The triple bottom line of sustainable agriculture," https://www.farmlandlp.com/2009/11/triple-bottom-line-sustainable-agriculture/#.YTKpK45KguU
[16] "TST issues brief: Sustainable agriculture," https://sustainabledevelopment.un.org/content/documents/1802tstissuesagriculture.pdf
[17] S. R. Gliessman and M. Rosemeyer (eds.), *The Conversion to Sustainable Agriculture: Principles, Processes, and Practices.* Boca Raton: FL: CRC Press, 2009.
[18] C. Sachs et al., *The Rise of Women Farmers and Sustainable Agriculture.* University Of Iowa Press; 2016.
[19] D. K. Verma (ed.), *Microbiology for Sustainable Agriculture, Soil Health, and Environmental Protection*. Apple Academic Press, 2021.
[20] K. Boole et al. (eds.), *Advances in Crop Modelling for a Sustainable Agriculture.* Burleigh Dodds Science Publishing, 2019.
[21] E. Lichtfouse (ed.), *Sustainable Agriculture Reviews*. Springer 2017.

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Figure 1 Sustainable agriculture has environmental, social, and economic dimensions [5].

Figure 2 Cattle in a biodiverse environment [7].

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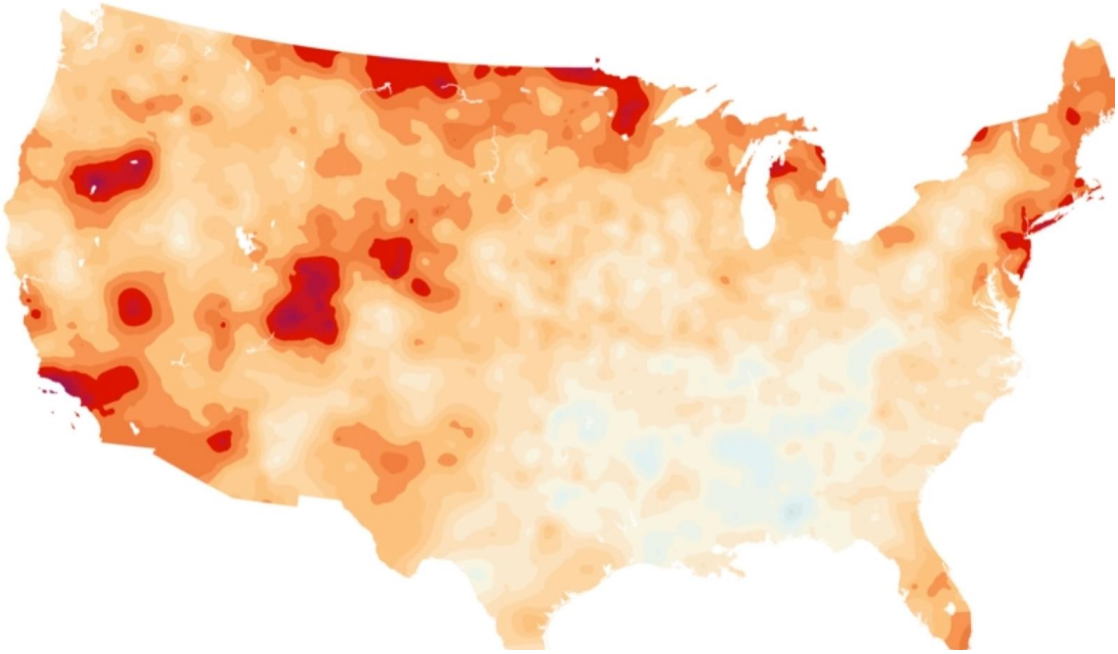

Figure 3 Climate change in America [10].

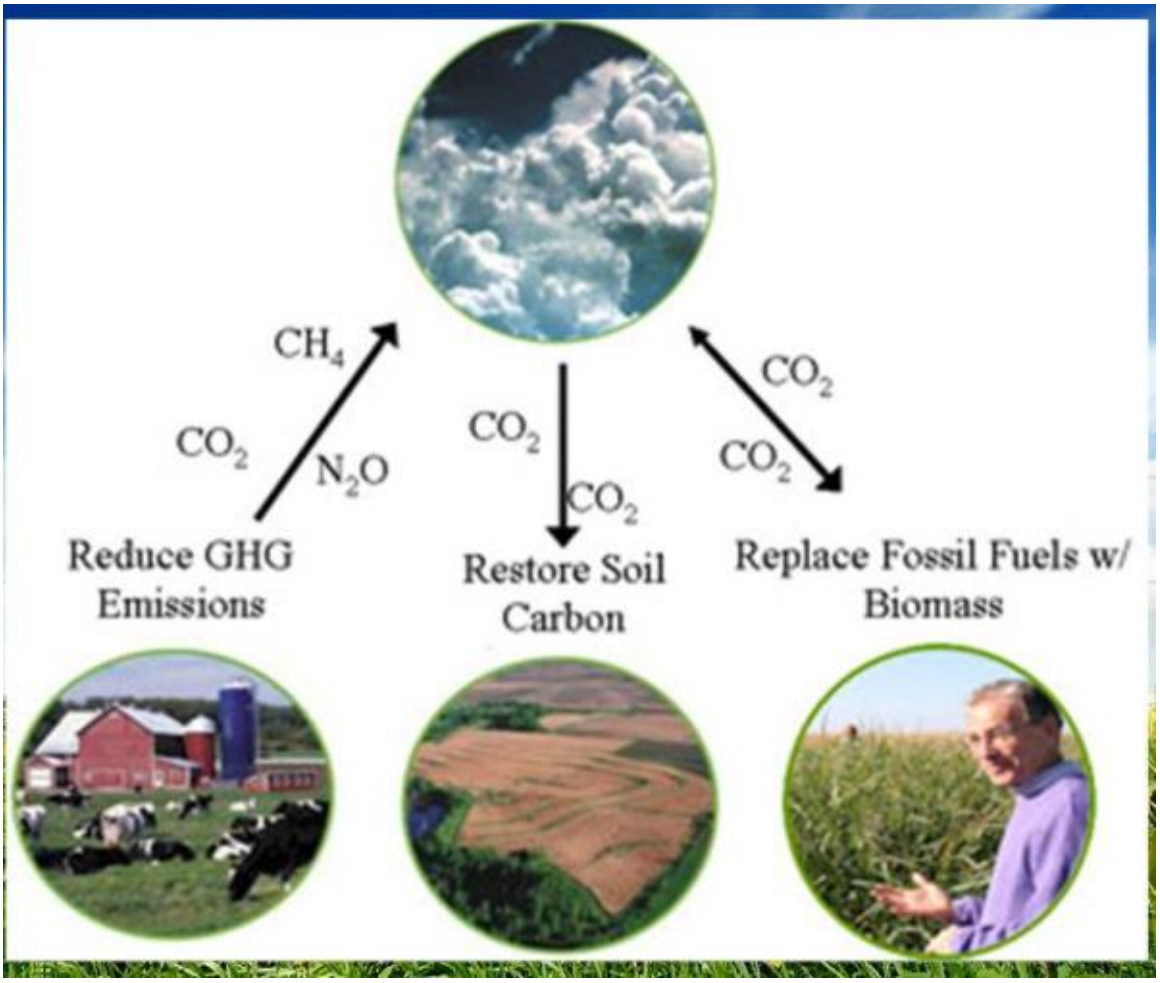

Figure 4 Benefits of sustainable agriculture [15].