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Review Article

Sustainable Agriculture: A Healthy Vision towards Food and Nutritional Security

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A B S T R A C T

Food security is a tiresome process, subject to risks of different natures. The risks can effect directly the various dimensions such as production of farming, food access usage, and stability. According to the United Nations, still more than 836 million people in the globe are living in utmost poverty. Progress is being continued combat against hunger, yet an unacceptably large number of people still, lack the food, and they need an active, healthy, and wealthy life. The recent and latest available estimates indicate that about 795 million people in the world just over one in nine were undernourished in 2014–2016. The share of undernourished people in the population or the prevalence of undernourishment has decreased from 18.6% in 1990–1992 to 10.9% in 2014–2016, reflecting fewer undernourished people in a growing world population. Changes in large populous countries, notably China and India, play a large part in explaining the overall hunger reduction trends in the developing regions. To meet the global population demand, sustainable agriculture is the immediate solution to produce increasing productivity. In this review, perspectives of various agricultural practices and focusing the deep understanding of sustainability in agricultural toward food security were discussed.

Keywords

Availability, Stability, Access, and utilization

Introduction

Food security is situation that exists when all people, at all times, have physical, social, and economic access to sufficient, safe, and nutritious food that meets their dietary needs and food preferences for an active and healthy life (FAO 2001). This definition comprises four key dimensions of food supplies: availability, stability, access, and utilization. The first dimension relates to the availability of sufficient food, i.e., to the overall ability of the agricultural system to meet food demand. Its subdimensions include the agro-climatic fundamentals of crop and pasture production (Tubiello *et al.,* 2007).

Food security is a broad concept, whose meaning and scope has evolved over the years, and traditional concepts of food security included simple measures such as national food production, food grain storage, national food self-sufficiency, and food aid. These were mainly macro indicators reflecting food supply, and which were used as a basis for developing conventional early warning systems against famine. In designing these systems, it was believed that such indicators could predict acute food insecurity and cause the relevant authorities to respond adequately through centralized distribution of national food reserves or food aid (Davies *et al.,* 1991).

Increased food consumption by a growing human population presents large challenges for agriculture, which are amplified by the effects of climate change, land degradation, and declining resources such as freshwater, phosphates, fossil fuels, and fertile topsoil. Over the next decades, annual crop yield is projected to grow with less than 1%, and there is very limited space for expansion of arable land (Alexandratos and Bruinsma 2012).

Overall demand for food is affected by population growth, while economic development and rising incomes tend to shift diets toward meat and animal products that are more expensive and resource intensive to produce (FAO 2010).

Conservation agriculture (CA) is a pragmatic tool for soil management in a sustainable way to get optimum productivity. Conservation agriculture encompasses minimal soil disturbance, permanent soil cover, diversified crop rotations, and integrated weed management. The introduction of CA has helped farmers worldwide to improve crop yields with substantial reductions in soil degradation and production costs. It also improves soil physical (less soil compaction, higher soil moisture, and SOM) and biological properties (increased microbial activity, soil enzyme activity, soil biomass carbon/N) (Kassam *et al.,* 2019).

Data from several long-term experiments on diverse soil types and climatic conditions indicate that the synthetic fertilizers alone are not sufficient to increase or sustain soil fertility, and may aggravate soil acidification. On the other hand, the sole use of organic fertilizers can improve soil fertility and quality, but the crop responses to sole organic amendments are slow. Moreover, the farmer in the region did not apply micronutrient to soil. Thus, application of micronutrients (e.g., Zn) (Nadeem *et al.,* 2020; Ullah *et al.,* 2020) and bio-inoculants, and the combined use of organic and inorganic (synthetic) fertilizers (micro and macro)/amendments (Srinivasarao *et al.,* 2019; Ali *et al.,* 2020), might be attractive options to improve soil health and crop productivity on a sustainable basis.

Policy in Improving Nutritious food

Socioeconomic factors such as people's education, women's empowerment, traditional beliefs, infant and young child feeding practices, intra-household food distribution, and social norms are considered determinants of people's access to passable and nutritious food, in addition to their dietary behaviors, and can themselves be affected by changes in diets along with nutritional impact. Food-based solutions to nurture the food security have surely subsidized to our facts on the efficiency of integrated approaches as these case studies validate and it is essential to emphasize these types of approaches when designing involvements. These food systems that ecological concepts can be of clear- cut use to study and improve the sustainability and nutritional value of the underlying food systems. Sustainable agriculture integrates three principal criteria such as environmental health, economic profitability, and social and economic equity.

Systematic Approach for Food Security

A systems perception is necessary to perceptive sustainability and is proposed in its comprehensive sense, from the individual farm, adapted to local ecosystem and to populations exaggerated by this farming system. So, systemic approach for sustainable food security provides an idea and tools to explore the network among the rural and other aspects of the environment. The custom and universal approaches besides indicate the interdisciplinary determinations in systemic research and education which impose not only the input of researchers from various disciplines but also farmers, farm workers, consumers, and policymakers. For agriculturalists, the progression to sustainable agriculture generally requires a sequence of trifling, realistic steps. The achievement on the way to the goal of sustainable agriculture is the obligation of all contestants in the system, including planters, work hands, legislators, researchers, vendors, and clients.

Sustain the Efficient Approach for Farmer Goals

Many inputs and practices used by conventional farmers are used in sustainable agriculture for crop productivity, and sustainable farmers, however, maximize reliance on natural, renewable, and on-farm inputs. Equally important are the environmental, social, and economic impacts of a particular strategy. Converting to sustainable practices does not mean simple input substitution. Frequently, it substitutes enhanced management and scientific knowledge for conventional inputs, especially chemical inputs that harm the environment on farms and in rural communities. The goal is to develop efficient, biological systems which do not need high levels of material inputs (FAO 1996).

Ultimatum of food in future prospects

Global food demand for agricultural crops is increasing and may continue to do so for decades, propelled by a 2.3 billion person increase in global population and greater per capita incomes anticipated through mid-century (Godfray *et al.,* 2010). Agriculture already has major global environmental impacts: land clearing and habitat fragmentation threaten biodiversity (Dirzo and Raven 2003). Land clearing and more intensive use of existing croplands could contribute to the increased crop production needed to meet such demand, but the environmental impacts and trade-offs of these alternative paths of agricultural expansion are unclear (Godfray *et al.,* 2010; GOS report 2011). About one-quarter of global greenhouse gas (GHG) emissions result from land clearing, crop production, and fertilization (Burney *et al.,* 2010), and fertilizer can harm marine, freshwater, and terrestrial ecosystems (Vitousek *et al.,* 1997).

A threefold consequences of challenge now faces the world (von Braun 2007): match the rapidly changing demand for food from a larger and more affluent population to its supply; do so in ways that are environmentally and socially sustainable; and ensure that the world's poorest people are no longer hungry. This challenge requires changes in the way food is produced, stored, processed, distributed, and accessed that are as radical as those that occurred. During the eighteenth and nineteenth century Industrial and Agricultural Revolutions and the twentieth-century Green Revolution, increases in production will have an important part to play, but they will be constrained as never before by the finite resources provided by Earth's lands, oceans, and atmosphere (Conway 1997).

Causes for Food Production

Rising Population

Majority of recent reports on the food crisis focus principally on population growth and an increasing demand for food. However, population growth is one of several demographic factors likely contributing to the current food crisis.

Urbanization is one of the key factors for fragmentation of agricultural lands due to population density. Most of the countries with the highest numbers of people facing food insecurity, however, have high fertility rates and rapid population growth which is cause of increases in the challenge of adequately meeting nutritional needs (UNPD report 2009).

The largest population increase in Asia, particularly in China, India, and Southeast Asia, accounts for about 60% and will increase the world's population by 2050 (UNPD 2007). However, the rate of population growth is still relatively high in Central America and highest in Central and part of Western Africa. Africa will experience the most rapid growth, over 70% faster than in Asia: annual growth of 2.4% versus 1.4% in Asia, compared to the global average of 1.3% and only 0.3% in many industrialized countries (UNPD 2007). Sub-Saharan Africa has the highest population growth rate in the world. By 2050, even if fertility rates decline, the population of the region is projected to more than double. This area also holds the largest proportion of food-insecure people, with one in four people undernourished (United Nations Population Division report 2009).

Sub-Saharan Africa has the lowest agricultural productivity in the world and the highest percentage of people living in poverty (World Bank report 2009). Food production depends on croplands and water supply, which are under strain as human populations increase. Pressure due to limited land resources, driven in part by population growth, can mean expansion of cropland. This often involves destruction of vital forest resources and overexploitation of arable land. Globally, the world is becoming more urban and although urban residents have access to a wider array of foods, without land to farm, their food security is dependent on their income and ability to purchase food products (FAO 2010). More than 200,000 people are added to the world food demand every day. The human population in the world has increased almost fourfold in the past 100 years (UNPD 2007).

Land Acquisition and Agriculture

Land is the basic for every form of physical development and constitutes the primary medium for food production for the provision of shelter and manufacturing utilities and the establishment of institutions to support the basic needs of modern communities (Lasun and Olufemi 2006). Land is the farmer's most important asset and plays essential role in increasing as well as sustain the agricultural production (Ukaejiofo 2009). Besides, the total land area available for agricultural production will be increasingly constrained by land requirements for other purposes, like infra- structure development, urbanization, bioenergy production, and biodiversity protection (Sands and Leimbach, 2003), but also by soil degradation (McNeill and Winiwarter 2004; Oldeman *et al.*, 1990).

The demand for agricultural land can be used for various purposes such as, urban, residential, industrial, commercial, recreational, educational, and other uses. Demand for agricultural land is mainly dependent on the price of agricultural land. The demand will be more when the price of agricultural land is low, and demand will be less when the price of agricultural land is high. Thus, there is an inverse relationship between demand for and price of agricultural land (Walter and Barnhart 2013).

Climate Change

Agriculture is inherently sensitive to climate variability and change, due to either natural causes or human activities. Climate change is caused by various anthropogenic activities such as emissions of greenhouse gases, industrial pollution, and deforestation which is expected to directly influence crop production systems for food, feed, or fodder, to affect livestock health, and to alter the pattern and balance of trade of food and food products. These impacts change differential pattern of warming and associated changes in rainfall. Climate change could have a range of direct and indirect effects on all four dimensions of food security. Hence, global climate change is an additional constraint to agricultural production in the second half of the twenty-first century. Increasing of atmospheric carbon dioxide levels and a corresponding rise in global temperatures will not only affect plant growth and yields but also alter the regional patterns of precipitation and water availability, as well as land erosion and fertility. Regional impacts of climate change vary quite significantly, with tropical regions potentially suffering from drought impact with combined effects of various changes are still highly uncertain. Impact of climate change on agricultural productivity will reduce the food crops and thus the expected land scarcity in 2050 (Nelson *et al.,* 2010). Many other simulations such as the effects of climate change with and without adaptation (induced technological progress, domestic policy change, international trade liberalization, etc.) and mitigation, for example, CO2 stabilization, variants for temperature, rain- fall change, and distribution (Darwin *et al.,* 1995).

Impact of Climate variations on Food making, Proffering and Availability

Climate change impacts on agriculture and food production in complex. It affects food production directly through changes in agro ecological conditions and indirectly by affecting growth and distribution of incomes and thus demand for agricultural produce. Impacts are quantifiable in numerous studies and under various sets of assumptions.

Changes in temperature and precipitation associated with continued emissions of greenhouse gases will bring changes in land suitability and crop yields.

Impact of Climate Change on Food Consumption

Climate change affects the ability of individuals to use food effectively by altering the conditions for food safety. The main concern about climate change and food security is that changing climatic conditions can initiate a vicious circle where infectious disease causes or compounds hunger, which in turn, makes the affected populations more susceptible to infectious disease and the result may be substantial decline in labour productivity and an increase in poverty and even mortality.

Essentially, all manifestations of climate change, they may be drought, higher temperatures, or heavy rainfalls, have an impact on the disease pressure, and there is growing evidence that these changes affect food safety and food security (IPPC Report 2007a, b).

Day by day Increasing Water Demand with higher rate of consumption

Population growth and economic development are driving significant increases in agricultural demand for water. Agriculture accounts for more than two-thirds of global water use including as much as 90% in developing countries. Freshwater consumption worldwide has been more than doubled since World War II and is expected to rise another 25% by 2030 (Daniel Wild *et al.,* 2007).

Significant role of Water in Agricultural Production

Freshwater and food production are indirectly connected; producing one ton of grain requires 1000 tons of water. Food production is so wholly dependent on water that agriculture can use 75–90% of freshwater in a region (WWO report 2010). Water scarcity creates food shortages, raises food prices, and increases a countries' dependence on food imports.

Management of problematic soils for Sustainable Agriculture

The challenges of global needs in facing agriculture are how to provide food for the increasing world population.

The human population is projected to reach nine billion people by the year 2050, and at the same time, the need to conserve the environment is another task (Spore 2012). Sustainable increase of agriculture involves the use of agricultural practices that are economically and environmentally sustainable which offers a useful approach to tackling food in security facing the world as the result of increase in population and environmental degradation which have long-term effect on agriculture globally (Simon *et al.,* 2013). In recent decades, agricultural land that was formerly productive has been lost to urbanization and other human uses, as well as to desertification, salinization, soil erosion, and other consequences of unsustainable land management (Nellemann *et al.,* 2009). Research into sustainable land management seeks to improve our understanding of the complex interdependencies between economic, environmental, and social conditions which affect the organization of the use of land and natural resources (Eppink *et al.,* 2012).

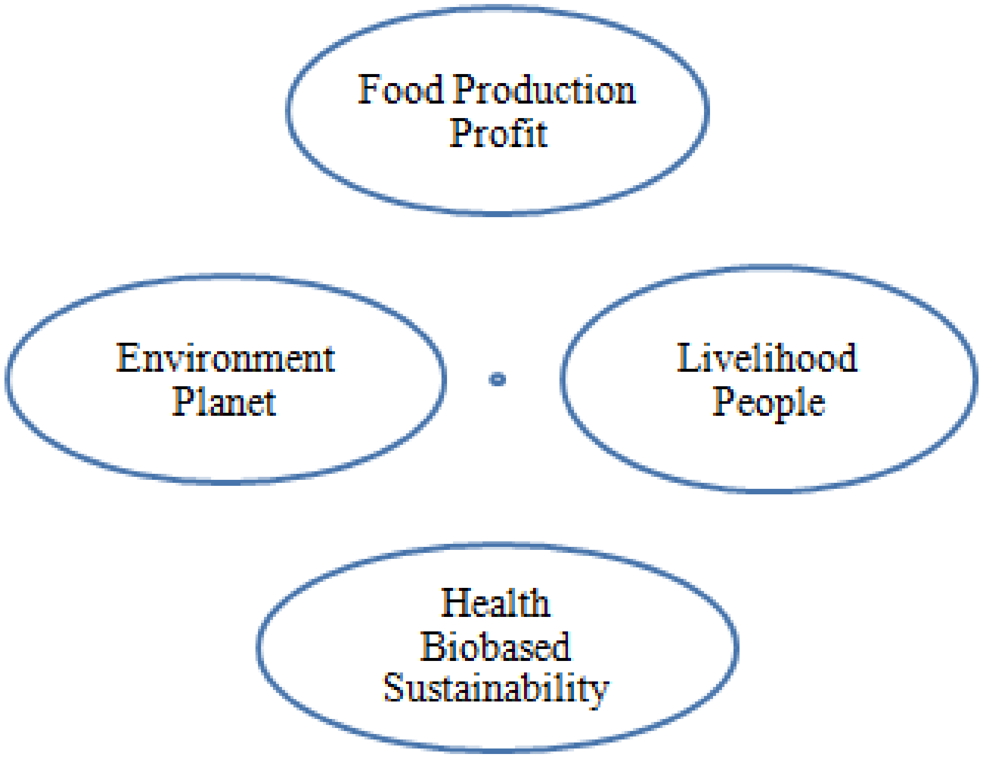
Cropping Systems and Sequence in Zones of Arid and Semiarid tracts

The main objectives for ecologically and economically sustainable agriculture are maintaining soil fertility and improving crop productivity and stability. Management options are site- and time-specific nutrient and water management, crop protection measures, and the choice of adapted, high-yielding cultivars. The effects of the various measures that are of importance for the maintenance and use of the resource base cannot easily be assessed within one growing cycle but should be evaluated over a sequence of crops. Crop rotation is an important component of an integrated approach of sustainable agriculture and resource conservation.

Short- and long-term effects of a cropping sequence and related management practices can be expressed in physical soil properties such as water-holding capacity and bulk density; chemical soil properties such as pH, carbon content, and nutrient contents and biological soil properties such as microbial activity (Lal 2008; Shibu *et al.*, 2006).

Growing special crops in a rotation can improve the sustainability of the cropping system (Struik and Bonciarelli 1997).

Fig.1 Efficient and efficacy of sustainable agriculture



Mixed Farming Systems in collaborations

Integration of crop and animal production on the farm and regional scales may be an opportunity to increase eco-efficiency apart from crop rotation (Wilkins 2008). Nitrogen is mobile in the soil-plant-animal system and with the required N inputs for high crop yields and intensive livestock production the risk of N losses increases (Van Keulen *et al.,* 2000). Traditionally, nutrient management has been concerned with optimizing the economic return from nutrients used for crop production. The main emphasis was on the expected crop response from adding nutrients to the soil.

Nutrient-Balanced Farm for sustainable farming

Nutrient imports are approximately equal to exports. Because these farms are often at the upper limit of being able to safely handle all the nutrients in the production system, nutrient management planning may offer potential environmental benefit. Agronomically, farmers should aim at the minimum input of each production resource required to allow maximum utilization of all other resources (De Wit 1992).

Farming (ease of doing) of Sustainable Agriculture

The sustainable agriculture generally classifies into three main objectives: economic profitability, environmental health, and ethical soundness. It is often presented as a conceptual three Ps framework: People-Planet-Profit (Fig. 1). The changes in agriculture from a purely profit-oriented activity into a three P-based production sector, trying to meet productivity, efficiency, and efficacy aims have been of considerable importance for sustainability (Matson *et al.,* 1997). The demand of resources such as water, land, and biomass and the rate of environmental degradation in a cumulative sense are increasing manifested by land salinization, groundwater pollution due to excessive leaching of fertilizer residues, and the pollution of surface water due to the poor or lack of treatment of trade effluents disposed into natural water resources (Government of India 2001).

Scarcity of water resources and reserves and Its Implications for Agriculture

Increasing water shortage would be a major challenge to achieving global food security (Leisinger 1996). The future demand for water in India is from all the four competitive use sectors, viz., agricultural, industrial, domestic, and livestock drinking for the year 2025 (Seckler *et al.,* 1998; GOI 1999; Ballabh *et al.,* 1999; Kumar 2001).

Technologies for enhancing productivity and efficiency of Sustainable Agriculture

Sustainability in agriculture relates to the capacity of an agroecosystem to predict- ably maintain production through time. A key concept of sustainability is stability under a given set of environmental and economic circumstances that can only be managed on a site-specific basis.

To a large extent, the rate of technology development and the degree of innovation in future technologies will greatly influence the stability and certainly the productivity of agriculture (Hutchins and Gehring 1993). Technology, in the classical sense, includes the development and use of nutrients, pest control products, crop cultivars, and farm equipment, but it also includes the vision of genetically modified crops providing greater nutritional efficiency (more calories per yield or more yield), manipulation of natural pest control agents, and use of farm management techniques that focus on whole farm productivity over time, not just annual production per hectare (Stone and Pedigo 1972). Several on-farm management practices in the Indian farmers can adopt in agriculture. These agricultural practices are particularly important for the semiarid regions which have already taken to intensive farming with irrigation water, both from canals and aquifers in some states of India (Kumar 2002). Such practices, if carried out consistently, it can progressively reduce the water requirement of the existing crops and improve primary productivity of the cultivated land. For alteration and gradual reduction of chemical fertilizers, Indian farmers are increasingly using the organic manure, vermin-culture technologies, and agronomic practices such as mulching, crop rotation, and the use of bio-pest control measures. Organic manure can help regain structure and texture of soils and enhance their moisture retention capacity along with improving soil nutrients. The use of farm management practices such as mulching can reduce the evaporation from soil surface, thereby increasing the efficiency of irrigation water utilization practiced by Indian farmers (Kumar 2002).

Global action toward food security is needed for the present scenario to ensure and sustain the food production to access adequate food for every human in the world.

Although many conventional techniques have existed since antique to make food production in agriculture, other new development strategies are also needed for sustainable agricultural practices.

Hence, depending on the demand of the food toward increasing world population in the future, the active and sustainable agricultural research is needed to fight against hunger and sustain the food security.

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Reference is made here to the developing regions as defined by the M49 country classification of the United Nations (see http://unstats.un.org/unsd/methods/m49/m49regin.htm). Countries included in these regions are also reported in Annex 1, Table A1

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