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REVIEW ARTICLE

Agriculture, sustainable development, environment, farmer knowledge and universities

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ABSTRACT

Society still faces serious environmental and socioeconomic problems, which have only been partially offset by the rapid development of knowledge, information technology, and technology; however, sustainable development remains a goal. This article aims to establish a debate on the contribution of agriculture to sustainable development and to analyze the role of the university in this process. Different alternatives to agricultural production that can contribute to sustainability are critically reviewed. These include good agricultural practices that seek to preserve the environment, including agroecology and organic agriculture, precision agriculture, and some applications of biotechnology. There is currently a need to establish evaluation methods that allow objective identification of progress or setbacks in the quest for sustainability. In the implementation of the concept of sustainable agriculture, universities have an essential role to play as the main source of scientific truth and center of knowledge, without detracting from the legitimacy and value of other epistemic systems such as peasant, traditional, or local knowledge.

Keywords: sustainability; farmer knowledge; environmental management; higher education; rural development

1. Introduction

In the environmental sphere, the increase in global temperature, the number of extinct or endangered species, deforestation, and land degradation are of great concern. But even more serious are the socioeconomic inequalities, with alarming rates of poverty, hunger, malnutrition, and infant mortality. Twenty-eight years ago, the Brundtland Commission coined the term sustainable development, understood as development that meets the needs of the present generation without compromising the ability of future generations to meet their own needs. However, society still faces serious problems that have not been overcome; on the contrary, some have increased.

Nevertheless, significant progress has been made during this period in the search for more democratic and inclusive societies[1]. In addition, the Millennium Development Goals were set to eradicate extreme poverty and hunger, achieve universal primary education, promote gender equality, reduce child mortality, improve maternal health, combat deadly diseases, ensure environmental sustainability, and promote a global partnership for development. In this context, the Hunger-Free Latin America and the Caribbean initiative was launched to eradicate hunger and ensure food security in the region[2].

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Likewise, in the last 20 years, there has been a vertiginous development at the level of knowledge, information technology, and technology, with a significant impact on the agricultural and food production sectors.

This period has brought new challenges, but also new options for solving the problems of today's world. In particular, in the agri-food sector, the concept of sustainable agriculture has evolved towards the search for environmentally sound, socially acceptable, and economically viable production of food and other products of plant origin[3].

The university faces challenges stemming from new conceptions of development, environment, knowledge, information, technology, globalization, ethics, democracy, and participation. It is clear that, in addition to its educational mission, it has acquired a greater commitment to research and its interaction with society. The purpose of this article is to establish a debate on the contribution of agriculture to sustainable development and to analyze the role of the university in this process.

2. Methods

A literature review was carried out to identify the problem and propose alternatives for sustainable development in agriculture.

3. Results

There are many problems that need to be addressed in the search for sustainable development in the environmental, social, and economic dimensions.

3.1. Environmental issues

The following environmental problems require solutions in the short term:

- Global temperature increase
- Species extinction (loss of biodiversity)
- Deforestation
- Land degradation

These irreversible or reversible impacts, which can only be reversed in the long term, require immediate action and high-level political decisions. However, few leaders are willing to assume the political cost of certain decisions aimed at alleviating or remedying these problems. This is evident in the ups and downs of the Kyoto Protocol summits. Montreal 2005 showed two clearly defined trends: one aimed at reducing emissions, and the other focused mainly on measures to adapt to global warming[4].

3.2. Socioeconomic problems

Despite the seriousness of the environmental problems mentioned above, the phenomena of poverty, hunger, malnutrition, low health coverage, and low levels of basic primary education that afflict a high proportion of the population, particularly in rural areas, are even more worrisome. This calls into question the scope of the Millennium Development Goals and the current development model. Inequities in trade and globalization, which disadvantage developing countries, are also highlighted. In the agricultural sector, subsidies for the production of developed countries are a serious limitation for weaker economies. Poverty and environmental degradation form a vicious circle. On the one hand, environmental conditions affect people's quality of life. A healthy and preserved environment provides space and resources for sustenance, is a basic condition for health and well-being, and even generates wealth; on the other hand, a degraded environment restricts livelihood possibilities, causes disease, makes the people who occupy it vulnerable, and necessarily leads to poverty. Poverty, in turn, affects the environment in several ways: it forces poor people to degrade the environment, promotes economic growth at the expense of the environment, and undervalues environmental concerns[5].

3.3. Problems in agricultural production

Increases in agricultural productivity have been made possible by increasing the use of energy from fossil fuels, such as machinery and agrochemicals. Intensification without environmental criteria has resulted in soil degradation and an increased risk of contamination of water sources with fertilizers, pesticides, soil particles, and post-harvest residues, as well as emissions into the atmosphere of greenhouse gases such as CO_2, methane, and NOX, and acidifying gases such as ammonium[6]. These negative ecological impacts have economic and social effects, to the detriment of the quality of life of rural producers and surrounding communities.

Although agricultural production has negative impacts on the environment, it is also affected by other productive sectors. This is the case of the use for agricultural purposes of water contaminated with industrial residues organic waste, or acid rain caused by the industrial and transportation sectors, which has caused considerable damage in rural areas of Europe[6]. The impact of global warming on agriculture, for which it is responsible, is considered to have a differential effect in time and space, depending on the agroecological systems, production methods and conditions, and the species cultivated.

3.4. Agriculture and sustainable development

Agricultural production can contribute in different ways to sustainable development: socially, if nutritious and safe food is produced at reasonable prices, jobs are generated, health risks are reduced and poverty is reduced. Environmentally: In environmental terms, if renewable and non-renewable resources are used efficiently, agrochemical losses due to percolation, volatilization, and erosion are reduced, soil quality is maintained or improved, and the risk of water pollution and greenhouse gas emissions into the atmosphere is minimized[7]; in economic terms, if wealth is generated and food trade is promoted.

New visions of ethics and the environment, rapid developments in knowledge and information societies, and technological advances are creating different alternatives for agriculture to provide real support for sustainable development. These include good agricultural practices (GAP), agroecology, organic agriculture, site-specific agriculture, the use of biotechnology, and, recently, renewed interest in the production of biofuels. However, it should be recognized that the very concept of agricultural sustainability is not universal; on the contrary, it is a debate between ecocentrist (focused on ecological objectives), humanist (focused on human development), and technocentrist (focused on technological development with a capitalist orientation) positions[8].

3.5. Good Agricultural Practices (GAP)

According to FAO[9], GAP consists of the application of available knowledge to the sustainable use of basic natural resources for the production, in a benevolent manner, of safe and healthy food and non-food agricultural products, while striving for economic viability and social stability. This implies knowledge, understanding, planning, quantification, recording, and management oriented to the achievement of specific social, environmental, economic, and productive objectives.

GAPs are basically born out of concern for the trend towards unsustainability and a lack of competitiveness in production systems, with activities that jeopardize environmental quality, human health, and the quality of food itself. Thus, GAPs are instruments for the environmental and social sustainability of agricultural production, which should result in the production of safe and healthy products for self-consumption and the market, with production processes that make rational use of available resources and promote a better quality of life. GAPs are also a component of competitiveness, enabling rural producers to differentiate their products from other suppliers, with economic advantages in terms of better prices, access to new markets, and consolidation of existing ones.

A framework of basic principles for GAP was developed in 2002, based on 11 elements, namely: soil management (including conservation agriculture, with minimal tillage, the permanent presence of vegetative cover, and appropriate crop rotation/association), water management, appropriate crop and variety selection, crop protection with environmentally benign practices (including integrated pest management, IPM), animal production welfare and productivity, animal health with environmentally sound practices, animal welfare, use of appropriate standards for harvesting, processing, and on-farm storage; efficiency in energy use and waste management, welfare, health and safety of people and workers, nature and landscape conservation[9]. The use of peasant knowledge is vital since peasant cultures, from all latitudes, have historically applied ecological and nature-friendly practices, are the least consumerist, and depend very little on external inputs.

3.6. Agroecology and organic agriculture

Agroecology is based on basic ecological principles for the study, design, and management of productive and conservationist agroecosystems of natural resources that are culturally sensitive, socially viable, and economically viable. Agroecology aims to achieve an understanding of the ecological and social levels of co-evolution, structure, and function; emphasizing the interrelationships between components and the complex dynamics of ecological processes, with a holistic conception of agroecosystems, including all environmental and human elements. Its fundamental principles are: increase biomass recycling and optimize the availability and balanced flow of nutrients, ensure favorable soil conditions for plant growth, particularly through the management of organic matter and soil biotic activity; minimize losses due to solar radiation, air and water fluxes through microclimate management, water harvesting and soil management with increased cover; specifically and genetically diversify the agroecosystem in time and space, increase biological interactions and synergies between biodiversity components by promoting key ecological processes and services[10].

Organic agriculture prohibits the use of synthetic inputs and allows only natural inputs in production systems. Internationally and in many countries, it is regulated by governmental and/or non-governmental bodies. These standards are mandatory and do not arise from a prior consensus among the actors in the chain, as is commonly the case with GAP; rather, in most cases it is the certifying agencies that design and implement these regulations. In general, the standards contain detailed lists of materials that are permitted, prohibited, or restricted. Prohibited materials include synthetic pesticides and non-natural fertilizers, some poisonous natural substances, growth promoters and hormones, and transgenics. Organic animal production systems only admit plant foods produced under organic conditions.

In addition, the products obtained must be kept separate from conventional products during industrial processing, and special requirements are established for additives and, in some cases, packaging. Certification includes annual inspections of farms and processing facilities, detailed reviews of production records and procedures, and traceability systems from the farm to the point of sale. Before a production system is classified as organic, a transition period of two to three years is required.

In the sustainability debate, there are critics of organic agriculture. It is argued that organic agriculture does not solve the problems of conventional agriculture and in many cases leads to similar (or even greater) risks. The problems common to both types of agriculture are soil erosion, nutrient losses to the environment, volatilization of ammonia forms, the presence and accumulation of heavy metals in the soil, and compaction caused by agricultural machinery. There is even scientific evidence that shows an increase in nitrogen losses to the environment and ammonia volatilization with the use and storage of manure. However, positive aspects are recognized due to the non-use of synthetic agrochemicals and better treatment of animals[11]. Another aspect of concern is the possible decrease in yields and therefore in the economic sustainability of alternative production systems, a situation that depends on better market prices[3].

In addition to the controversies surrounding agroecology and organic agriculture, there are certain limits and restrictions to their development, in terms of policies, institutions and research agendas[10]. The development, transfer, and adoption of alternative conceptions of agricultural production require more research and strong extension systems to make them accessible to farmers[12].

3.7. Precision agriculture

Computers, geographic information systems (GIS), global positioning systems (GPS), and the development of machinery and equipment have facilitated site-specific agriculture (SSFA), also called precision agriculture, which seeks to optimize the production process based on the variability of the agroecosystem[13]. AEPS allows greater knowledge of the production system, facilitates the rational use of inputs, and can improve productivity, which brings considerable technical and economic benefits[14]. A relevant feature of AEPS is the use of the required inputs at the indicated site and at the recommended dose, which reduces their losses to the environment (e.g., agrochemicals and water) and improves energy efficiency. However, SCAP does not always lead to environmentally sound practices, especially when the farmer increases input dosage in order to obtain higher financial returns[15].

The SPRE requires a considerable volume of information, so its collection must be systematic. Leiva[16] proposes four basic phases for the development of SPRE systems: a) measurement and data collection, b) data analysis and information generation, c) establishment and application of site-specific management systems (decision making), and d) evaluation and monitoring. The different phases require more or less sophisticated technologies, including GPS, satellite information, sensors, computers, and equipment capable of applying inputs with variable doses. However, this concept can be used in less developed production systems with simpler technologies[17]. The benefit-cost ratio of SCBA remains a limit to its implementation unless policies are established to value and financially recognize verifiable environmental benefits[18].

3.8. Biotechnology applications

Biotechnology and information technology applications have opened up unsuspected possibilities for a new approach to agricultural production. Biotechnological aspects have led to the manipulation of genes (the very basis of life) and the development of genetically modified organisms (GMOs), with improvements in crop productivity and a reduction in the use of agrochemicals. However, GMOs are the subject of acute controversy between proponents and detractors due to their ethical implications and possible damage in the medium or long term[19].

3.9. Sustainability assessment

The integration of social, environmental, and economic objectives that endure over time is in itself a challenge, which is more complex in light of the sustainability debate. This has led to the generation of methods for evaluating the sustainability of specific systems, which serve as instruments for decision-making and for defining government policies. The interest has focused particularly on the generation of indicators[20]; that is, derived variables that summarize information about a relatively complex process, a trend, or a situation, in an easily understandable way[21]. In addition, in decision-making, indicators provide reliable information and allow comparison with values that have the connotation of threshold, objective (goal), reference, or comparison[22].

3.10. University and sustainable development

The university is the institution par excellence for generating and proposing new conceptions of development and the role of knowledge, information, and technology in society. In particular, universities with programs for the agricultural sector have a great responsibility oriented toward sustainable development, the generation of knowledge, the training of professionals, specialists, and researchers, and social projection (extension).

However, this leadership is sometimes elusive, especially in the generation of knowledge and in processes of change in our universities. The greatest research challenge for agricultural universities in the tropics is the generation of knowledge on tropical agriculture since this is a geographic region of immense natural wealth, diverse but equally fragile. In terms of social projection, our universities must develop and implement effective extension systems that gather the results of research in technologies appropriate to our environment, reach and positively impact the rural sector, and provide innovative solutions to implement sustainable production systems.

The function of the university is projected and vitalized to assume (or recover) its transformative role, promote ethical values, preserve nature, affirm diversity, and closely link society with the community. These approaches can easily be connected with the boom and interest in recognizing, recovering, and disseminating peasant knowledge (different terms have been used, such as traditional knowledge, ethnoscience, indigenous knowledge, or local knowledge). It is proposed that the university should be an active agent in the legitimization and learning of peasant knowledge, which implies accepting that scientific knowledge is a form of knowledge, and requires humility and openness to engage in a dialogue of knowledge.

In terms of education, universities with agronomy programs should evaluate and strengthen their undergraduate and graduate programs. The new conceptions of agriculture must be an integral part of undergraduate programs, so that they are approached rigorously, with a critical spirit, without dogmatism, and with a high ethical sense. However, adding isolated courses to the curriculum is not the solution. On the other hand, the supply of postgraduate courses must be increased with high-level specialization or research programs that will help to overcome the current limitations in the knowledge of tropical agriculture and train critical masses capable of addressing the new challenges of the agricultural sciences in the 21st century. These changes require strengthening the quality of our educational systems, with better financing and infrastructure, an adequate number of highly trained professors, and updated systems of self-evaluation and accreditation.

4. Conclusions

The current problems in the environmental and socioeconomic dimensions call into question the real scope of the very concept of sustainability and question the current development models. Agricultural production can contribute to the achievement of social, environmental, and economic objectives through different alternatives. However, since there is debate about the concept and its practical implications, it is necessary to establish evaluation methods that allow for the objective identification of progress or setbacks in the search for sustainability. Universities must take the lead in education, research, and extension to propose solutions aimed at overcoming the problems that particularly afflict the rural sector and putting sustainable agriculture into practice without disregarding the traditional or local knowledge of farmers, which has always been consistent with the protection of the environment.

Conflict of interest

The authors declare no conflict of interest.

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