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The Scientific Basis and Present Status of Sustainable Agriculture

Naoki Sakai

Director, Agricultural and Forestry Research Center, University of Tsukuba,
Tsukuba, Ibaraki 305-8577, Japan

Sustainable agriculture (SA) plays an important role in constructing, maintaining, and improving a sustainable society. In this paper, I review the numerous definitions of SA proposed by several organizations throughout the world and present some common components and problems. I then introduce some elements from the first comprehensive report on sustainability in Japan, which was published by Research on the Scientific Basis for Sustainability. Finally, I emphasize that many serious problems and conflicts remain to be solved.

Key words: Sustainable agriculture, Sustainable society, Definition, Future prospect, REBS report

Introduction

From the viewpoints of a stable food supply and environmental conservation, sustainable agriculture (SA) plays an important role as an essential tool in constructing, maintaining, and improving a sustainable society. It is important that we make progress in SA research so that sound food production systems can be harmonized with regional and global ecosystems as soon as possible. Many serious and complex problems still, however, must be surmounted. Examples include (1) reducing the amount of artificial agricultural inputs (e.g., petroleum products) while maintaining a comfortable quality of life, and (2) obtaining a satisfactory food supply while minimizing environmental impacts. These problems are objective and methodological, whereas other questions are more related to a timetable. For example, "When will we arrive at the ultimate goal of a sustainable society?" or "Is it possible to fulfill the goal of a rich, sound, and fair society before environmental complications become too severe?" Obtaining solutions and answers may not be easy, and the gradual development of effective and systematic approaches, including research, education, extension services, and policy-making, will be required.

In this paper, I briefly review some definitions of SA, review the results of the first large-scale report on sustainability in Japan, and examine future directions in sustainability research.

Approaches to a Sustainable Society

Sustainable Society and Education for Sustainable Development

Adachi (1998) adopted three components for constructing a sustainable society, (1) population (or economic activity), (2) resources and energy, and (3) the global environment. An Education for Sustainable Development (ESD) Programme was proposed and approved at the World Summit on Sustainable Development (WSSD) in Johannesburg, South Africa, in 2002. In 2004, the Japan Council on the UN Decade of Education for Sustainable Development (ESD-J), a group of non-governmental and non-profit organizations, included various educational activities for gender, welfare, multiculturalism, development, environment, human rights, peace, and other aspects as the essence of ESD (ESD-J, 2008).

What is SA?

The word sustain means "to keep in existence and maintain," and it implies long-term support or permanence. Generally, SA is considered to be resource-conserving, socially supportive, commercially

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Corresponding author's current address: Director, Agricultural and Forestry Research Center, University of Tsukuba, Tsukuba, Ibaraki 305-8577 Japan. E-mail: nsakai@sakura.cc.tsukuba.ac.jp

competitive, and environmentally sound (John Ikerd, 1990, cited from USDA, 2008).

Figure 1 shows a simple triangle expressing the relationships among three SA components, (1) reducing artificial inputs and enforcing circulation functions, (2) reducing environmental impacts on atmosphere, water and soil, and (3) raising and stabilizing holistic productive efficiency. Human factors, including quality of life, human welfare, and human rights, have been purposefully excluded because they are complicated to practically and quantitatively analyze, despite their importance. Some other examples of words, phrases, and concepts used to define SA are given below.

When defining SA, the American Society of Agronomy (2009) used the phrases, (1) satisfy human food and fiber needs, (2) enhance environmental quality and the natural resource base upon which the agriculture economy depends, (3) make the most efficient use of nonrenewable resources and on-farm resources and integrate, where appropriate, natural biological cycles and controls, (4) sustain the economic viability of farm operations, (5) enhance the quality of life for farmers and society as a whole.

The U.S. Congress stated that SA should, (1) satisfy human food and fiber needs, (2) enhance environmental quality and natural resources, (3) make efficient use of nonrenewable resources, (4) integrate controls, (5) sustain economic viability, and (6) enhance the quality of life for farmers and society (U.S. Congress, 1990, cited from Kansas State University, 2008).

The Organization for Economic Cooperation and Development (OECD, 2008) defined SA to be economically viable agriculture that does not degrade the environment over the long term. The FAO (2008) stated SA, (1) conserves land, (2) conserves water and plant and animal genetic resources, (3) does not degrade the environment, (4) is technically appropriate, (5) is economically viable, and (6) is socially acceptable. The Alliance for Sustainability (2004) adopted the four essential concepts of ecological soundness, economic viability, social justice, and humaneness.

McGill University in Canada adopted four important characteristics of SA, (1) productivity (productive efficiency), (2) stability (constancy), (3) sustainability (free from stress and confusion), and (4) equitability (fair distribution among the sectors) (McGill University, 2008). However, the Texas Agricultural Extension Service adopted profitability, the environment, and quality of life as critical components in establishing SA (Texas Agricultural Extension Service and Prairie View A & M Cooperative Extension Program, 2008).

The United Nations Environment Programme (UNEP) expanded the concept of SA to "SARD" (Sustainable Agriculture and Rural Development). The aim of SARD is to increase food production in a sustainable way and enhance food security. The main tools of SARD are policy, agrarian reform, participation, income, diversification, land conservation, and improved management of inputs (UNEP, 2008).

Common components from the various definitions include the following; (1) an anthropocentric view is taken, (2) ecological considerations are based on understanding the role of nature, (3) a long-term view is taken (over generations), (4) practical

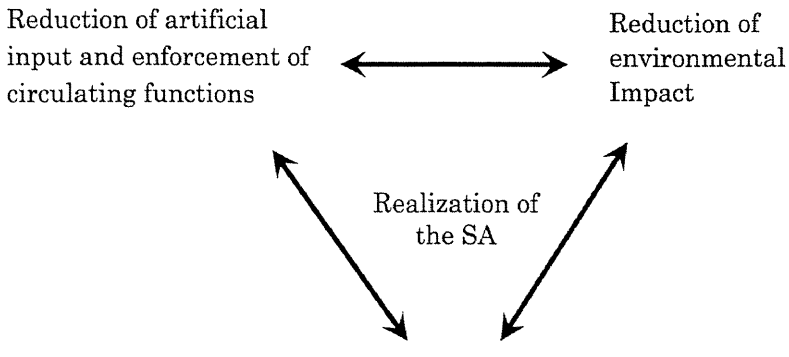

Fig. 1. An approaching example to the SA

consideration is given to the economic value of resources and products, and (5) unexpected circumstances are considered.

The question arises whether the use of the word sustainable is truly appropriate. Some of the definitions of SA are vague, and better overall agreement is needed on what is meant by the term sustainable. A system can easily continue as long as abundant artificial inputs of energy and resources are provided, but can such a system be called sustainable? Recently, the concept of self-sustainability has been proposed. The stocked entropy of earth is increasing as a result of human activities and the stagnation of entropy flow.

Figure 2 shows an example of endless action through the continuous supply of energy and resources to the systems. A spinning top can continue easily and permanently against the effects of gravity and mechanical friction if the required spinning power can be supplied without interruption.

SA in Japan

Japan's Ministry of Agriculture, Forestry and Fisheries (MAFF) considers SA to be agricultural practices that are either "environmentally conscious" or "environmentally friendly." To promote a better balance between agriculture and the environment, MAFF (2008) supports; (1) improving soil quality with manure and appropriate use of fertilizer and chemicals and (2) recycling rice straw and livestock manure. In practice, MAFF recommends reducing the amount of fertilizer and chemicals in soil, adopting suitable methods for pest management to avoid excessive application of chemicals, adopting crop rotation to avoid damage by continuous cropping or excessive application of fertilizer, and using crop residue, rice straw, rice husk, and garbage as compost.

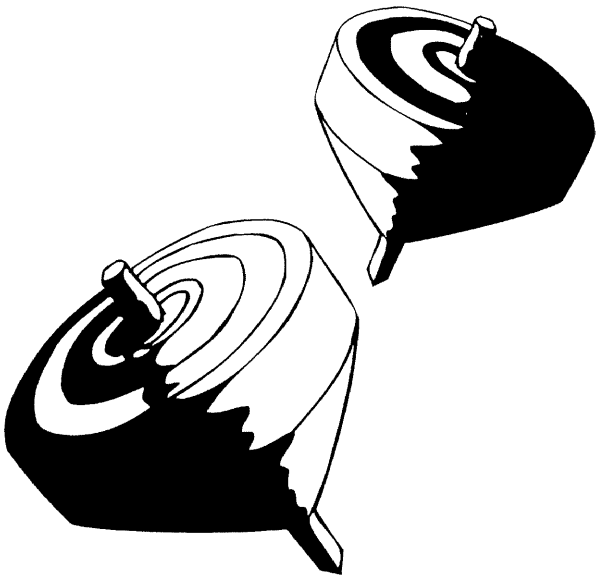

Fig. 2. An example of endless action by the continuous supply of energy and resources to the systems

"Science on Sustainability 2006"

The report "Science on Sustainability 2006" was published by Research on the Scientific Basis for Sustainability (REBS, 2008). This effort represented the first detailed report of the state of scientific knowledge of sustainability in Japan. The project was proposed by the Science Council of Japan, and about 170 scientists, including me, from the various parts of the world took part. The report restricts future projections to within 50 years in consideration of the limits of forecasting precision.

The UN Brundland Commission published "Our Common Future" in 1987, and in it they emphasized the concept of intergenerational responsibility in sustainable development. They also stressed that continued social and economic development are necessary to achieve sustainability and that unlimited growth is impossible with finite limits.

One question the report addresses is, "Will there be a large-scale food crisis in the future?" The dominant view among the scientists interviewed is that the main problem is not the actual amount of food available but the distribution of food. Another point made is that meat and dairy production have increased over the past 40 years. If everyone were to adopt an American-style diet, it is likely that a global food-supply crisis cannot be avoided.

The present status of grain production and consumption was also examined. The FAO has globally estimated that (1) the rate of global grain production decreased after peaking in 1980, (2) grain production per capita decreased from 377 kg in the 1990s to 329 kg in 2003, and (3) food productivity will need to increase by as much as up to about several times by 2050.

When asked how to increase food production, the majority of the scientists interviewed said that (1) using genetically modified crops was not a good

option, (2) sustainability and SA cannot succeed without long-term vision, and (3) new and innovative food production systems are required to replace the systems put in place during the "Green Revolution" in 1960s.

Conclusions

In this paper I presented a brief review of the present status of SA, including its scientific basis. Unfortunately, I confirmed that some problems still remain. Some questions remain unanswered, including, "What kind of society will be designed in the future?" and "How are we going to approach abstract and long-term goals?" Answering these questions will require more than one solution. We must continue research and other efforts, including education, extension services, and political activities for intergenerational responsibility, as emphasized by the Brundland Commission. The discussion and actions must be spread over a wide area and a long term to be successful.

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