The Viewpoints of Sustainable Agriculture within the System Approach in Agriculture

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Abstract

This article has aims to present the current perception of sustainable agriculture within the systems approach. Sustainable agriculture is multi-layered and covers at component everything which correlated farm to ecology systems and livelihoods system. The sustainable evaluation within systems theory should have objectives for defining the boundaries of sustainable systems and use system properties or system behavior to explain the relation between sub-systems or components in the system. Thus, scholars should consider the function and interaction of sub-systems in order to provide an accurate analysis and reach an understanding of sustainable agriculture. Sustainable agriculture is one system with a multi-dimensional perspective, and we should therefore use the systems approach in analysis. However, the topic should take into account the philosophical principles of the individuals and organizations involved as well as relevant technology and management to discover the ways these various components interact to form the practice of sustainable agriculture.

Keywords: Sustainable agriculture, systems approach in agriculture, viewpoint

Introduction

Agriculture systems are at the heart of developing countries' economies and family livelihood. A rapidly transforming world poses considerable challenges to rural smallholders with limited are resources (e.g. land, money, knowledge, technology, labor etc.), challenges that range from globalization and poverty to pandemics and climate change. Agricultural development is explored within this dynamic context in farming systems (Phiri, Wellard, & Snapp, 2008, pp. 1-25). The evolution of agriculture research is traced from simplistic commodity-focused improvement to innovation systems approaches. In the 1970s, agriculture had the rapid rural appraisal (RRA) methodology arise to study the community context and found weak points in the RRA process (Grandstaff, et al., 1987. pp. 1 - 30). This method combined the research techniques of social sciences and anthropology, and at some point combined with other sciences to study community environments. In the 1980s, most agro-ecological system research was implemented in consideration of yield effects and yield optimization on the field scale and with a matter dynamic in small watersheds. This approach gave short- to mid-term results in regard to implementing land-use systems (Schroder, Huber, Reents, Munch, & Pfadehaure, 2008, pp. 1-16). In terms of system approaches in agriculture, factors such as human systems, environmental systems, livelihood systems, economic systems, social systems, and technology all come into the activities. However, if one wants to understand systems of agriculture the context for farmers must also be understood.

Many organizations have tried to devise definitions, indicators, and guidelines for sustainable agriculture and the farmers who practice it. There is still a question as to the benefit of placing sustainable

agriculture in the context of a system approach and how this might change its definition. The aim of this article is therefore to explore agriculture using a systems approach.

Briefing a History of Agriculture

Mazoyer and Roudart wrote *Histoire des agriculteurs du monde* in 1933, and translated by Memebrez in 2005. In the book presented to around 12,000 years ago, a new technique for making tools began to develop: polishing stone. This new technique opened the last period of prehistory, the Neolithic, which lasted until the appearance of writing and metallurgy. In addition to the axes and adzed that could be made by polishing all sorts of hard stones and sharpening them several times, this epoch was marked by other innovations, such as the construction of long-lasting dwellings, terra-cotta pottery, and the first development agriculture. Blij, & Murphy (2003, p. 593) posed the question "Where did plant domestication begin?" Cultural geographer Carl Sauer (references in Blij, & Murphy, 2003, p. 593) suggested that Southeast Asia has been the scene, more than 14,000 years ago, of the first domestication of tropical plants. There, report of Blij, & Murphy (2003, p. 593) believed, the combination of human settlements, forest margins, and freshwater streams might have given rise to the earliest planned cultivation of root crop (i.e., crops that are reproduced by cultivating either the roots or cutting from the plants). A similar but later development might have taken place in northwestern South America.

The planned cultivation of seed plants (plants that are reproduced by cultivating seeds) is a more complex process, involving seed selection, sowing, watering, and well-time harvesting. Again, the practice seems to have developed in more than one area and at different times. Some scholars believe that the first domestication of seed plants may have occurred in the Nile River Valley in North Africa, but the majority view were that this crucial development took place in a region of southwestern Asia, through which flow the two major rivers of present-day Iraq: the Tigris and the Euphrates, so the document similarly with Scarre, & Fagan (2003, p. 555) wrote in book title "Ancient Civilization" to livelihood and practice with food searching in Aksum (A.D. 100 – 1,100), at era has cultivation cereal crop and used animal power for plowing land before planting. This marked the beginning of what has been called the First Agricultural Revolution, and the area where it occurred is known as the Fertile Crescent. The grain crops, wheat and barley, grew in the warming Southwest Asian climate. When rainfall diminished as the inter glaciation wore on, the river-inundated plains of Mesopotamia provided alternate, irrigable fields for farming.

However, world development is dynamic, human population increasing according to natural resources. In the 1960s was beginning of the Green Revolution, which had prediction an impact on global malnutrition. The Revolution constituted a various of the contemporary agricultural revolution but without the large-scale motorization and mechanization, developed widely in the developing countries. Based on the selection of varieties of rice, maize, wheat, and soya, a heavy utilization of synthetic fertilizers and pesticides and, if necessary, on firm control over water for irrigation and over drainage, the Green Revolution was adopted by farmers capable of acquiring these new means of production in regions where production was possible to realize a return on their investment. However, as regards the Green Revolution, in several countries, public powers have greatly favored the diffusion of this revolution by the adoption of policies of agricultural price supports, subsidies for input, preferential interest rates for

borrowing, and investment in the infrastructure for irrigation, drainage, and transport. At present, a farmer fully utilizing the mean of the green revolution can attain raw labor productivity on the order of 100 quintal (1 quintal = 100 kilograms) of cereal equivalent if that farmer has only manual tools (1 hectare/worker 100 quintal/hectare), on the order of 500 quintals if they have equipment that used animal power (5 hectares/worker 100 quintals/hectare), and even more if the farmer can make several harvests per year (Mazoyer, & Roudart, 2005, p. 529). Another impact of the Green Revolution was the high cost for production per cropping, especially in smallholders at a disadvantage in production cost and marketing (Gimenez, Altieri, & Rosset, 2006). In addition, in the Silence Spring wrote by Carson (1962, p. 15-37), so explain with impacted agriculture in terms of chemical usage in agriculture section.

What is sustainable agriculture?

Sustainability is the ability of a system to maintain its productivity when subjected to stress and shock. A stress is defined as a regular, sometimes continuous and cumulative, relatively small and predictable disturbance. Examples are increasing soil salinity, declining soil fertility, failing of a resistant variety affected to plant disease, and farmer's indebtedness. A shock, by contrast, is an irregular, infrequent, relatively large and unpredictable disturbance. Examples are relatively infrequent drought or flood, a new pest, or a major political upheaval. Sustainability is also viewed as the system to maintain a given level of productivity over an extended period of time. Unfortunately, measurement is difficult and can often only be done retrospectively. According to lack of sustainability may be indicated by declining productivity in the farming, but equally, as experience has shown, collapse can come suddenly and without warning (Conway, 1987, pp. 95-117; Marten, & Rambo, 1988, pp. 263 - 285).

The concept of sustainability within agriculture systems is difficult to define, both because of its scope and the abstraction of the term itself. Roling, & Wagemaker (1998, pp. 3-22) express a similar opinion, that it is possible to view sustainable agriculture from widely different perspectives at different levels. However, sustainable agriculture at a small scale is self-sustainable, which reduces risk (Chambers, Pacey, & Thrupp, 1989, p. 218; Chantalakhana, & Skunmun, 2002). We must therefore consider that sustainable development does not mean sustaining economic growth rate, because economic growth is impossible to sustain if it depends upon ever increasing quantities of resources from ecosystems with limited capacities to provide the resource (Marten, 2001, p. 238; Altieri, 1992, pp. 1-21).

According to Simaraks, et al., (2010), some systems may be disrupted or destroyed but can recover and be restored to their original condition or even better in a short time and in the report of Chantalakhana, & Skunmun (2002) there are references to the concept and goals of sustainability by TAC/CGIAR in 1989, for example that "sustainable agriculture should involve the successful management of resources for agriculture to satisfy changing human needs while maintaining or enhancing the quality of the environment and conserving natural resources".

However, sustainable agriculture is multi-layered, and everything is correlated. It's important to define terms and set objectives for sustainable systems first before considering relationships among sub-system or components. Nevertheless, you can see the present relationship of components which sustainable agriculture concept in Figure 1.

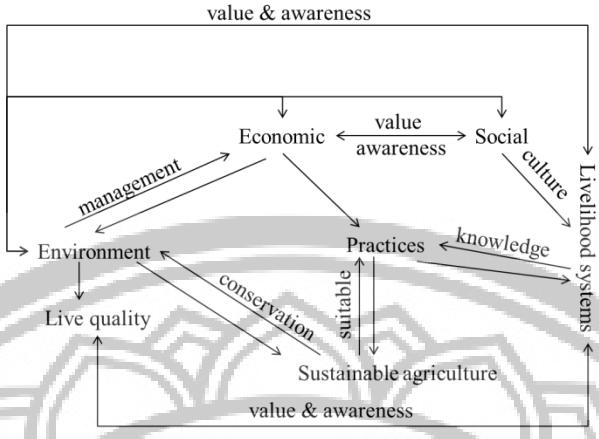

Figure 1 Concept of sustainable agriculture

Why sustainable agriculture?

The aim of agriculture production is providing food to support human survival, but world development involves industrial processes and chains of large businesses competing within the economic system, while medical care improves, increasing human longevity at an increasing pace. Ehrlich, & Ehrlich (1988) reported to the world population in the 19th century was 1.5 billion and by the 20th century would be around 2 billion, which related to a report of the United Nations (2013) that the world population has 2 billion in 2013. However, from data reported by the web site Wordometers (2014) in July 2013, the current population in the world was 7.13 billion. The population is increasing too fast, but the area suitable to food production constitutes about 1% of the world (International Rice Research Institute, 2013), and we thus find an imbalance. The Green Revolution of the 1960s used modern and/or heavy technology for agriculture production, and the similar perspective of Pesek (1993, pp. 1-20) reported a similarity with the beginning of sustainable agriculture because the rate of population increase was high, and agriculture production had to find a way to produce an amount of food suitable to support all of humanity. However, a report of Simaraks, et al., (2007) described how fear of unsustainability affected food production, cultural production, and overall human livelihood. Chantalakhana, & Skunmun (2002) discuss how to sustainable agriculture provides guidelines for research and development, which allow successful management of resources for agriculture to satisfy changing human needs while maintaining or enhancing the quality of the environment and conserving natural resource. However, UNESCO (2010) realized a correlation with the population increasing and the limited condition of natural resources and how this may induce famines. UNESCO therefore set up a sustainable agriculture training program with farmers, in the content of programs, where they discussed many aspects related to sustainable agriculture such as knowledge and beliefs of farmers, agricultural patterns, biodiversity, social systems, ecology, and politics. These relations of component are shown in Figure 2.

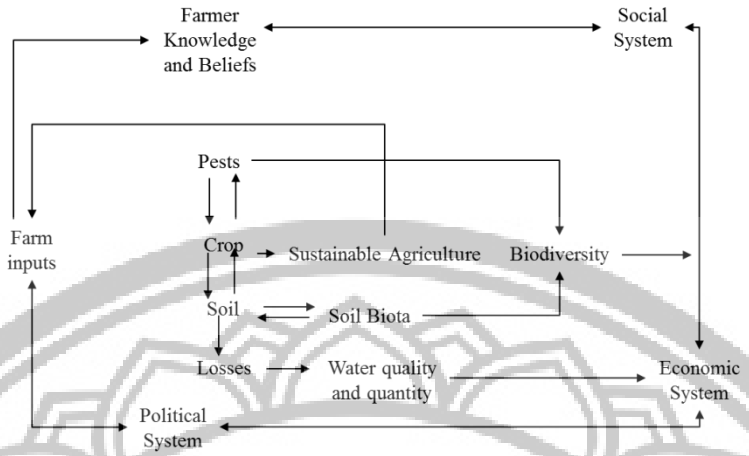

Figure 2 Component of resources related with sustainable agriculture

Source: UNESCO, 2010

Concept of systems approach in agriculture with sustainable agriculture

A systems approach defines interrelated elements or what are called "sub-systems." (Marten, 2001). The sub-systems can be molecules, organisms, machines or their parts, social entities, or even abstract concepts (Gallopin, 2003, pp. 1-42), and are related with ecological systems and human social systems. However, when considering with ecological systems, in the view of Rambo and Sajise (1984) they are also made up of mutually interacting components, describable in broad terms in this case as climate, soil, water, plants and animals rather than stars and planets. Besides, we're refer to these separate elements as comprising a system because each individual component exerts influence on and, in turn, is influenced by every other component. Climate, for example, affects the growth of vegetation but, in turn, is modified by the action of plant life (e.g., tree server to reduce wind speed and increase relative humidity level). Soil is formed through a combination of climatic and biological actions but, in turn, affects the growth of plants and animals. Human social systems are also made up of interacting components. For simplicity's sake we will speak of only four of the many possible components: population, technology, social structure and ideology. Again, as in the case of the bodies in the solar system or physical and biotic components of an ecosystem, each component of the human social system exerts an influence on every other component and is also influenced in its own behavior by those other components.

However, ecological systems and human social systems in the present economic system exert influence over other systems, because nature is a limited resource, so Wojtkowsik (2008, p. 293) explainer to exemplify plants in that they do growing not always benefit from a resource-rich site, so due to a shortage in one limiting resource, the full site growth and yield potential may not be reached. For example, a water-loving species, such as rice, will find water severely limited if planted in a dry environment. Caldecott (2008, p. 262) explains that with regard to water distribution it is limited based on the geography of an area as well as population activity. For example, in the metropolises of Thailand, rain makes transportation and other activities difficult, yet it's favored in rural areas that

depend more heavily on agriculture. However, as explained above of the system approach in agriculture, it is important to establish definitions first (Voinov, 2008, p. 416) prior to beginning analysis and synthesis. This is important, for example, in cropping systems, when considering plot levels and nutrient balance in the soil. (Manaligod, & Cuevas, 1998, pp. 133-162) economic factors (Kroeksakul, 2010) as well as human capital (Villavicencio, 2009, pp. 49-72) also play a great role in discussions of agriculture today, and they must be responded to through the selection of an appropriate farming technology. In the report of Rambo and Sajise (1984) allege, in a framework for rural resource system analysis, that it is based on the assumption that there are systemic relations between human society (the social system) and the natural environment (present in Figure 3). These relations affect the ability of humans to obtain needed resources as well as the environmental impacts produced by human activity.

Figure 3 Systemic relations between social system and eco systems (Apply form: Rambo, & Sajise, 1984)

How well do we understand sustainable agriculture? The question is complicated, but many academicians develop indicators that incorporate the technology, management groups, and other networks (King, Gunto, Freebbairn, & Webb, 2000, pp. 631-642). However, sustainable agriculture is related to systems properties (in terms of agroecology; Conway, 1987, pp. 95-117). Subhadhira, Simaraks, Samert, & Limpinuntana (1987, pp. 79 - 101) gave the example of when, during the Green Revolution era, the government focused on increasing productivity, farmers responded by using many raw materials such as chemical fertilizer, chemical pesticides, chemical herbicides and also heavy technology, which impacted the stability of productivity in those areas. Economic disparities will only continue between region, therefore a systems approach should be used to consider issues from different perspectives.

Still, sustainability analysis is a field that must perform the difficult task of predicting the future, and methods or particular concepts in farmer are not enough to predict the direction of sustainable agriculture.

Sustainability in distribution

Sustainability is related to timing, so when explaining the framework of sustainability one must consider the distribution of time and space as well as value and patterns. For example, sustainability in agriculture is a form of system management and is part of the area of human sustainability, such as in the case of sustainable rice production systems in lowland paddy fields, where it means the land distribution in rice production continues for a long time.

Timing is important in systems because if a system is slowed or a component in the system is broken, but the system is resilient and continues to function despite a setback, that system is considered sustainable (Holling, 1973, pp. 1-23). The distribution of time and space relates to other factors, such as the nutrient density of soil if outflow in the land may be impacted in terms of plant productivity, or in agricultural systems with their heavy fluctuation like in the Green Revolution era, when farmers had to change their practices (e.g. small scale to large scale, use labor in the household to use a machine etc.) and technologies (e.g. tractor, spay machine, chemical fertilizer etc.).

The value of agricultural production was also changed, in order to respond to world development systems, causing changes in terms of equilibrium, authority, unity, productivity, etc. However, if the concept of system properties is used (Conway, 1987, pp. 95-117; Marten, 1986. pp. 326 - 340), the results from sub-systems will impact the larger systems, such as in plant production where there is an interaction with soil, air, water, and farmer activity; therefore, productivity and sustainability are matters of system behavior.

Sustainable with system properties

Sustainability depends on system properties or system behavior, whether the ecological system (Holling, 1973, pp. 1-23) or agro-ecological system (Odum, 1984, pp. 5-12; Conway, 1987, pp. 95-117) features include productivity, stability, or equality. However, Marten and Rambo (1988) has noted additional social properties such as autonomy and solidarity and argued that features might be adaptive or dynamic. When referring to sustainability in one system to guide the analysis, synthesis should consider several features simultaneously, because these features are related more or less, depending on the system.

Attempting to increase agricultural productivity using an elaborate system may affect the sustainability of the ecosystem (Kroeksakul, & Simaraks, 2013, pp. 543-549). Thus, reducing it such as in the use of chemical pesticides, effects of environmental pollution, resistance of pests, or loss of self-reliance (Conway, 1987, pp. 95-117).

The reliance on external demands suggests a change in the system of cultivation or the adaptive practices of the farmer, which altered the unity among various household system. However, the promotion of sustainability could still be seen at the household level, as in the sharing of rice seedlings when rain was due to come soon after a drought. Such household practices can ensure continuous planting.

Sustainability in system hierarchy

The concept of systems hierarchy has existed for a long time, especially in the ecological systems (O'Neill, Deangelis, Waide, & Allen, 1986, p. 253), where some component have criticized the relationship of classes in the systems, including the function level of ecological systems (Conway, 1987, pp. 95-117). However, agro-ecosystems have provided a level within the world level (Lager) to social systems (unit) as presented in Figure 4.

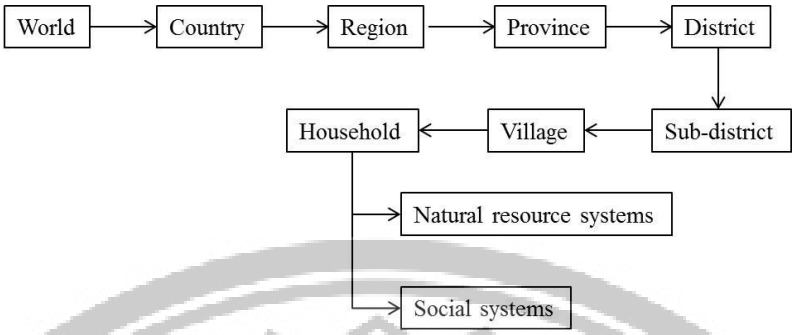

Figure 4 Example systems hierarchy of agro-ecology systems
Source: Simaraks, Luangmanee, & Pongsiri, 2003

The figure is presented in each hierarchy will be smaller than the system itself, and each system has a composition with a small system, sub-system, or makes up a larger system, and the larger systems will predominate the lower system. For example, the household systems of farmers have an influence on cropping systems, so before the farmers decide to product or the cropping depends on many components within the systems, and depending on the influence of the community also the market superior level. In addition to the influence of higher level, one should consider the influence of the different systems, which may exist at the same level. For example, if there is a disaster in one country that makes it so some plants can't grow. Therefore various countries has their own effects on the global market in terms of production and need.

Conclusion

When considering the analysis of sustainable agriculture, one must consider its sub-system and various components and other relationships, whether positive or negative. In the key of analysis is to have access to reliable information and cover all perspectives prior to analysis. However, in a sustainable agriculture analysis, one researches history and the present in order to make predictions about the future, yet there may be unforeseen factors that can affect sustainability. Nevertheless, to analyze it must to requires an understanding of sustainable agriculture as one system with a multi-dimensional perspective, so when using the systems approach, one should consider the philosophical principles of individuals and organizations involved as well as the technology and management that affect sustainability.

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