“Summary of article by Gordon Conway: Sustainable Agriculture” in Frontier Issues in Economic Thought, Volume 6: A Survey of Sustainable Development. Island Press: Washington DC, 2001. pp. 168-172

**Social Science Library: Frontier Thinking in Sustainable Development and Human Well-being**

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> Agriculture is a science which teaches us what crops are to be planted in each kind of soil, and what operations are to be carried on, in order that the land may produce the highest yields in perpetuity.
>
> -- Marcus Terentius Varro, *Rerum Rusticarum*

Thus did Marcus Terentius Varro, a Roman landowner of the first century BC, define sustainability in agriculture. In our time Varro's clarity of meaning has been lost as "sustainability" has become a highly politicized term. The diversity of opinions as to its meaning put forth by agronomists, economists, and environmentalists may be useful in gaining consensus for radical change, but is often too abstract for farmers. This article discusses the specific meaning of sustainability in terms of agricultural practice.

**Ecology and Sustainability**

The emergence of ecology as a sophisticated discipline gives a basis for a definition of agricultural sustainability which is scientific, open to hypothesis-testing and experimentation, and also practicable. Population, community, and ecosystem ecology provide a better understanding of the complex dynamics that arise in agriculture, for example in crop populations, multiple-cropping systems, agroforestry, and range management. Research centers such as the Centro Internacional de Agricultura Tropical (CIAT) in Colombia, and the Multiple Cropping Center at Chiang Mai University in Thailand have begun to develop a body of research on complex agricultural systems such as the rice fields of northern Thailand and the savanna ecosystems of Zimbabwe.

Agricultural systems such as the Thai ricefields can easily be recognized as modified ecological systems. Each field is formed from the natural environment, with a ridge of earth serving as its boundary. Inside, the great diversity of the original wildlife is reduced to a limited set of crops, pests, and weeds, but still retains some of the natural elements, such as fish and predatory birds. Natural ecological processes such as competition between rice and weeds, herbivory of the rice by pests, and predation of the pests by fish and birds, are overlaid with the agricultural processes of fertilization, control of water, pests, and disease, and harvesting. These agricultural processes are, in turn, regulated by economic and social decisions. The boundaries of the socio-economic system are not as easy to define as the biophysical ridge boundary of the field, but together they form an agroecosystem.

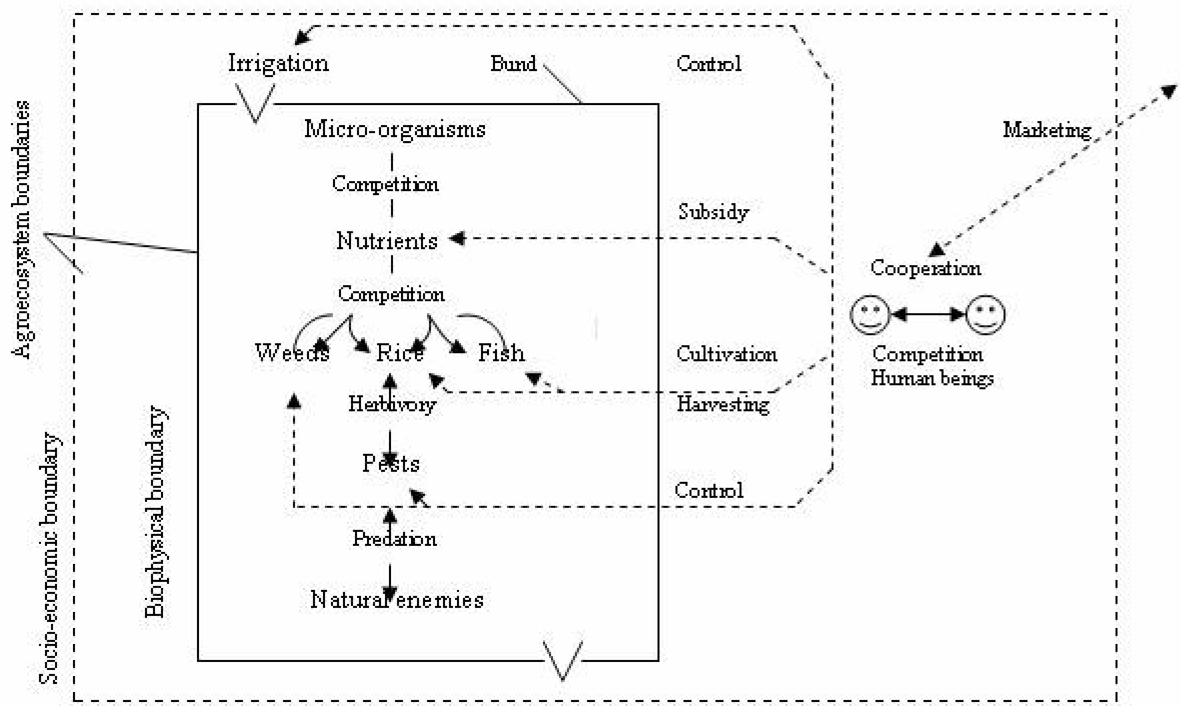


**Figure V.1.** The Ricefield as an Agroecosystem (from original Figure 9.1)

More formally, an agroecosystem is "an ecological and socio-economic system, comprising domesticated plants and/or animals and the people who husband them, intended for the purpose of producing food, fiber, or other agricultural products."[1] An agroecosystem can be evaluated in terms of *productivity*, *stability*, and *sustainability*. Productivity measures output per hectare, stability measures variability of production from year to year, and sustainability can be assessed as the ability of ecosystems to maintain productivity over time, and to rebound from stress or shock.

One way of improving sustainability is to protect the ecosystem from stress, for example by using ridges to protect fields from flooding. For pest control, the development of inherent genetic resistance and the use of biological or integrated control methods tend to be more sustainable than the use of pesticides. The stress caused by removal of nutrients during harvesting can be countered by applying fertilizers, or by boosting natural fertility through nitrogen-fixing legumes or composts. Shifting cultivation and the use of fallow periods also restore soil fertility. Economic sustainability may be promoted by producing a mix of crop and livestock products, using labor-saving cultivation techniques in response to emigration, or switching to higher-value, lower-volume products to lower transportation costs.

An important issue is the choice between external resources such as fertilizers and pesticides, and internal resources such as natural pest predators, algae, bacteria, and green manures, agroforestry and multiple cropping, and indigenous tree, fish, and crop species. Internal resources, which are often free to the farmer, have an economic advantage over purchased external resources. Dependence on external resources may be both costly and risky, since it puts the farmer at the mercy of sudden changes in price and availability. External resources such as the "Green Revolution" package of hybrid seeds, fertilizers, and pesticides may also lead to changes in farming systems which make them more vulnerable to the vagaries of the local environment.

**Equitability and Trade-Offs**

In addition to productivity, stability, and sustainability, the performance of an agroecosystem can be evaluated in terms of *equitability*. "An African village that has a high, stable yield of sorghum, using practices and varieties that are broadly resistant to pests and diseases, might be regarded as more successful than another village having lower, less stable, and sustainable yields. However, it is not only the pattern of production that is important, but also the pattern of consumption. Who benefits from the high, stable, and sustainable production? How is the harvested sorghum, or the income from the sorghum, distributed among the villagers? Is it evenly shared or do some villagers benefit more than others?" (175) In commercialized agroecosystems, benefits are divided between producers and non-producers. Trade-offs between productivity, sustainability, and equitability, and between producer and consumer interests, are common.

The Green Revolution has generally favored high productivity at the other indicators. We are now entering a new phase of development in which much greater attention will have to be paid to stability, sustainability, and equitability in addition to productivity. The object of the Doubly Green Revolution is to minimize the trade-offs between objectives.

An example of effective minimization of trade-offs is found in the home gardens of Indonesia. The most prominent characteristic of home gardens is their great diversity relative to their size. In a Javanese home garden of little more than half a hectare, fifty-six different species of useful plants were found, with uses for food, condiments and spices, medicine, and livestock feed. The plants are grown in an intricate relationship with one another, so that the garden seems like a miniature forest. The food produced goes primarily for home consumption, but some is bartered or sold. These home gardens display high productivity, stability, sustainability, and equitability.

**Farm Households and Livelihood Goals**

In addition to diversity, home gardens epitomize the importance of farm household decision-making. Complex multi-generational and extended family structures are common in farm households. The role of women is particularly important both in production and in access to food and nutrition security. The displacement of women by agricultural mechanization has had severe effects on poor households, lowering household income and worsening children's access to food. Time stress on women can also adversely affect breast feeding and children's nutrition.

The balance of livelihood goals involves a complex decision-making process, which takes place within the structure of traditional customs, rights, and obligations. Livelihoods often involve a combination of land husbandry, natural resource harvesting, off-farm employment, and handicrafts. Amerindian groups in central Brazil, for example, divide their time between gardening, hunting, and fishing, with variable patterns depending on local habitats. The sustainability of these livelihoods depends on their diversity, and potential innovations such as new crops should not conflict with existing effective patterns of activity.

Livelihood analyses should form an essential part of any development program. Unfortunately, few such analyses have been undertaken. While there is great potential in agricultural innovation, including biotechnology, this potential must he harnessed wisely in the interests of poor communities. Development planners, farmers, and field and laboratory scientists must collaborate in responding to the socio-economic needs of poor households. "We need a shared vision based, above all, on partnership, among scientists and between scientists and the rural poor." (182)

**Notes**

1. G.R. Conway (1987).