AGROECOLOGY: ENVIRONMENTALLY SOUND AND SOCIALLY JUST ALTERNATIVES TO THE INDUSTRIAL FARMING MODEL

Miguel A. Altieri
University of California, Berkeley, USA

Keywords: agroecology, agroforestry systems, traditional agriculture, organic farming, sustainable development, biodiversity**.**

Contents

Summary

Two main forms of alternative agriculture which sustain yields without agrochemicals, increasing food security while conserving natural resources, agrobiodiversity, and

ecological integrity prevail in the rural landscapes of the world: a more commercial form of organic agriculture and a peasant based more subsistence-oriented traditional agriculture. In this chapter, the agroecological features of organic agriculture as practiced in North America and Europe, and of traditional agriculture involving millions of small farmers and peasants in the developing world, are described with emphasis on their contribution to food security, conservation/ regeneration of biodiversity, and natural resources and economic viability.

1. Introduction

In July 2003, the International Commission on the Future of Food and Agriculture published the Manifesto on the Future of Food. This report warns that corporately controlled, agrochemically based, monocultural, export-oriented agronomic systems are negatively impacting public health, ecosystem intensity, food quality, traditional rural livelihoods, and indigenous and local cultures, while accelerating indebtedness among millions of farmers and their separation from lands that have historically fed communities and families. The growing push toward industrialization and globalization of the world's agriculture and food supply is increasing hunger, landlessness, homelessness, despair and suicides among farmers. Meanwhile, it is also degrading life support systems and increasing alienation of peoples from nature and the historic, cultural and natural connection of people to their sources of food and sustenance. Finally, it is also destroying the economic and cultural foundations of societies, undermining security and peace, and creating a context for social disintegration and violence.

Despite the above trend, microcosms of intact traditional, community-based agriculture offer promising models for promoting biodiversity, sustaining yield without agrochemicals, and conserving ecological integrity. New approaches and technologies involving application of indigenous knowledge systems and spearheaded by farmers, NGOs and some government institutions are increasing food security while conserving natural resources, agrobiodiversity, and soil and water integrity. Agroecology emphasizes the capability of local communities to innovate, evaluate, and adapt themselves through farmer-to-farmer research and grassroots extension approaches. Technological approaches emphasizing diversity, synergy, recycling and integration, and social processes that value community involvement, point to the fact that human resource development is the cornerstone of any strategy aimed at increasing options for rural people and especially resource-poor farmers. Two main forms of this alternative agriculture dominate; a more commercial form of organic agriculture and a peasant based more subsistence-oriented traditional agriculture. In this report, the agroecological features of organic agriculture as practiced in North America and Europe, and of traditional agriculture involving millions of small farmers and peasants in the developing world, are described with emphasis on their contribution to food security, conservation/ regeneration of biodiversity, and natural resources and economic viability.

2. Agroecology and Sustainable Agriculture for Small Farmers in the Developing World

2.1. Extent of Peasant Agriculture

Although estimates vary considerably, about 1.4 billion rural people in the developing world remain directly untouched by modern agricultural technology. The great majority of these people are peasants, indigenous people and small family farmers, who mostly still farm the valleys and slopes of rural landscapes with traditional and/or subsistence methods. About 370 million of these people are extremely poor and live in the developing worlds highly heterogeneous and risk prone marginal environments of the south. Rural poverty disproportionately afflicts the elderly, women and children. Also the majority of the indigenous people (80 % of some 19-34 million found in Mexico, Colombia, Guatemala and the Andes, but also millions in Africa and Asia) are poor. The great majority of poor farmers have meager holdings, with little or no capital. Most of their diverse framing systems do not rely on synthetic chemical pesticides or fertilizers use low input technologies such as native seeds, manure, plant biomass and other local resources.

It is estimated that there are some 960 million hectares of land under cultivation (arable and permanent crops) in Africa, Asia and Latin America, of which 5-10% of this land could be considered as managed by peasant farmers. This estimate includes 4.42 million small farms (< 5 ha) using sustainable agricultural practices on 3.58 million hectares plus the millions of peasants, family farmers and indigenous people practicing resource-conserving subsistence farming or that are in conversion to agroecological management guided by NGOs or other institutions (Table 1).

Region	**Number of farmers**	**Area (hectares or %)**	**Contribution to food security**
Latin America	a)16 million peasant units b) 50 million indigenous people	38% of total land devoted to agriculture, about 60.5 million hectares	a) 41% of food crop consumed domestically b) Half of humid tropics in Mexico and Amazon
Brazil	4.8 million family farmers	30% of total agricultural land	50% of land devoted to food crops
Cuba	1612 cooperatives and individual peasants	1.5 million hectares	10% of all food crops
Africa	a) 60-80% labor force involved in agriculture b) 70% of population living in rural areas (about 375 million) of Sub-Saharan Africa	100-150 million hectares	80% of cereals 95% of meat
Asia	200 million small scale rice farmers	a) 7.3 million hectares of upland rice b) 20.5 million hectares of rainfed rice	200 million people supported by upland shifting cultivation
Global estimate for developing world	50-100 million small holder family units	40-90 million hectares	30-50% of basic food crops

Table 1. Partial distribution and extent of traditional-peasant agriculture in the developing world

In Latin America in the late 1980s, the peasant population included 75 million people representing almost two thirds of the Latin America's total rural population. About 16 million peasant production units, averaging 1.8 hectares and totaling close to 60.5 million hectares, or 34.5% of the total cultivated land accounted for approximately 41% of the agricultural output for domestic consumption, including 51% of the maize, 77% of the beans, and 61% of the potatoes consumed at a regional level. In Brazil, about 4.8 million family farmers (about 85% of the total number of farmers) occupy 30% of the total agricultural land and control about 33% of the area sown to maize, 61% of that under beans, and 64% of that planted to cassava, thus producing 84% of the total cassava and 67% of all beans. In addition, many of the 4 million landless families live in the rural areas of Brazil are now turning to agroecology because of new initiatives encouraged by the directives of MST (Landless movement). In Ecuador, the peasant sector occupies more than 50% of the area devoted to food crops such as maize, beans, barley and okra. In Mexico, peasants occupy at least 70% of the area assigned to maize and 60% of the area under beans. In Cuba the peasant and small farm cooperative sector occupies 22% of the island's arable land (about 1.5 million ha.). Since 1990 virtually all this land has been devoted to food crops and is managed organically (most of it non-certified) as imports of fertilizers and pesticides fell drastically in 1984. In addition to the peasant and family farm sector, there are about 50 million individuals belonging to some 700 different ethnic indigenous groups who live and utilize the humid tropical regions of the world. About two million of these live in the Amazon and southern Mexico. In Mexico, half of the humid tropics is utilized by indigenous communities and "ejidos" featuring integrated agriculture-forestry systems with production aimed at subsistence and local-regional markets.

In Africa in the 1980s, the majority of farmers, many of them women, were smallholders with 2/3 of all farms below 2 hectares and 90% of farms below 10 hectares. Most small farmer's practice "low-resource" agriculture based primarily on the use of local resources with little or no use of fertilizers and improved seed but may make modest use of external inputs. Low-resource agriculture produces the majority of grain; almost all root, tuber and plantain crops, and the majority of legumes (Table 2). This situation has changed in the last two decades as food production per capita has declined and Africa, once self-sufficient in cereals, now has to import millions of tons to fill the gap. Despite this increase in imports small farmers still produce most of Africa's food.

In Asia, only a few of the more than 200 million rice farmers farm more than 2 ha of rice. In China alone there are probably 75 million rice farmers who still practice farming methods similar to those used more than one thousand years ago. Local cultivars, grown mostly on upland ecosystems and/or under rain-fed conditions, make up the bulk of the rice produced by Asian small farmers.

Crops	***External input use***	**% of crop produced by low-resource agriculturists**
Millet	Virtually no use of fertilizers and very little use of improved seed.	72%

Sorghum	Basically the same situation as millet, but hybrids and commercial inputs are becoming more important in some areas	61%
Maize	At least 75 percent produced without hybrid seeds and with less than recommended fertilizer levels; but probably as much as two-thirds produced with non-hybrid improved seed and moderate levels of fertilizer.	37%
Rice	At least 75 percent produced using less than recommended levels of fertilizer and receiving inadequate irrigation (and no more than 5 percent using High-Yielding Varieties).	76%
Food legumes (e.g. cowpeas, pigeon peas, beans, and groundnuts)	Most crops of this diverse group receive virtually no commercial inputs, but some production is under higher-resource conditions (e.g., up to 50 percent of groundnut production).	55% groundnuts 49% beans
Roots, tubers, and plantain (e.g., cassava, yam, cocoyam, and sweet potato)	Virtually no use of fertilizers or improved seed. Some high-resource banana production for exports.	93% cassava 100% yams 100% cocoyam

Table 2. The contribution of low-external input agriculture to African staple food production (after Office of Technology Assessment 1998. Enhancing agriculture in Africa: a role for US development assistance. Washington DC.,OTA-F-356, US Government Printing Office

Due to poverty (the bulk of farmers in the developing world are small holders who have small parcels and earn less than 2 dollars per day) and scale biases of modern technology, less than 25% of the total small farmer's population benefited from agricultural modernization. In Mexico less than 12%of the peasants adopted high-yielding varieties, while 11% adopted pesticides and no more than 25% adopted fertilizers. In the Andes less than 10% of the smallholders had access to fertilizers and new potato seeds. There is a large indigenous farming population who have never used elements of modern agronomy, mainly due to tradition and because their production systems do not require external inputs. There are also thousands of farmers who by their own initiative or as part "institutionally sponsored interventions", are now transitioning towards low-external input agriculture. A case in point are the FAO-sponsored farmers field schools in Asia, which have pioneered a totally different approach to IPM innovation scaling it up to a point where in Indonesia alone more than 1 million small-scale rice growers have now been trained. In Africa there are at least 730,000 households covering about 700 thousand hectares that have adopted sustainable agriculture practices. In Asia, this figure rises to about 2.3 million households distributed on 1.75 million hectares.

2.2. Agroecological Features of Traditional Farming Systems

Traditional farmers have developed and/or inherited complex farming systems, adapted to the local conditions helping them to sustainably manage harsh environments and to meet their subsistence needs, without depending on mechanization, chemical fertilizers, pesticides or other technologies of modern agricultural science. Indigenous farmers tend to combine various production systems as part of a typical household resource management scheme.

Traditional agroecosystems are found throughout the developing world, linked to centers of origin and genetic diversity. Some of these systems include:

- Outstanding terraced mountain sides with rice and complex agroecosystems in Asia (e.g. the Cordillera Mountain Range, Philippines; biodiverse systems in the Himalayas and Andes; and Mediterranean fruit gardens.
- Complex agro-silvo-pastoral and aquatic system and diverse tropical/subtropical home gardens, producing multiple foods, medicines, ornamentals and materials,(e.g. East Kalimantan and Butitingui, Indonesia; highlands of Rwanda and Uganda; Titicaca in Peru; Kayapo in Brazil).
- Traditional soil and water management systems for agriculture, including ancient water distribution systems allowing specialized and diverse cropping systems in Iran; traditional valley bottom and wetland food management (e.g. Lake Chad, Niger river basin and interior delta).
- Specialized dryland systems, including outstanding range/pastoral systems for the management of grasses, forage, water resources and adapted indigenous animal races e.g. Maasai in East Africa; pastoral systems of Ladakh, Tibet, parts of India, Mongolia and Yemen, as well as oases in deserts of North Africa and Sahara and indigenous systems in pays Dogon, Mali and pays Diola, Senegal.

Factors and characteristics underlie the sustainability of multiple use systems include:

- Farms are small with continuous production serving subsistence and market demands;
- Farm systems are based on several cropping systems, featuring mixtures of crops, trees, and/or animals with varietal and other genetic variability;
- There is maximum and effective use of local resources and low dependence on off-farm inputs;
- Energy inputs are relatively low;
- Labor is skilled and complementary, drawn largely from the household or community relations with dependency on animal traction and manual labor;
- There is heavy emphasis on recycling of nutrients and materials;
- Systems build on natural ecological processes (e.g. succession) rather than struggling against them.

Most peasant systems are productive despite their low use of chemical inputs. Generally agricultural labor has a high return per unit of input. In most multiple cropping systems developed by smallholders, productivity in terms of harvestable products per unit area is higher than under sole cropping with the same level of management. Yield advantages can range from 20% to 60%. These differences can be explained by a combination of factors which include the reduction of losses due to weeds, insects, and diseases and a more efficient use of the available resources of water, light and nutrients. In Mexico, 1.73 ha plot of land has to be planted with maize monoculture to produce as much food as one hectare planted with a mixture of maize, squash, and beans. In addition, the maize-squash-bean polyculture produces up to 4 t ha-1 of dry matter for plowing into the soil, compared with 2 t in a maize monoculture. In Brazil, polycultures containing

12,500 maize plants ha-1 and 150,000 bean plants ha-1 exhibited a yield advantage of 28%.

-
-

-

Bibliography

Altieri, M.A. and C.I. Nicholls (2004). Biodiversity and pest management in agroecosystems. Haworth Press, New York. [Comprehensive analysis of complex farming systems].

Altieri, M.A., (1995). Agroecology: the science of sustainable agriculture. Westview Press, Boulder. [This book describes the key principles of sustainable agriculture and expounds on management systems that work]

Altieri, M.A. (2002) Agroecology: the science of natural resource management for poor farmers in marginal environments. Agric. Ecosys. Environ. 93: 1-24. [Agroecology provides the scientific basis to address the production by a biodiverse agroecosystem able to sponsor its own functioning].

Beets, W.C., (1990). Raising and sustaining productivity of smallholders farming systems in the Tropics. AgBe Publishing, Holland. [Interactions between agro-technical, environmental, economic, sociological, institutional and political aspects].

Funes, F. et. al. (2002) Sustainable agriculture and resistance: transforming food production in Cuba. Food First Books, Oakland. [Cuba's remarkable recovery from a food crisis brought on by the collapse of trade relations with the former Socialist Bloc and the tightening of the US trade embargo came about by the use of sustainable agriculture, organic farming, urban gardens, smaller farms, animal traction, and biological pest control].

Gliessman, S.R., (1998). Agroecology: ecological process in sustainable agriculture. Ann Arbor Press, Michigan. [Theoretical and conceptual framework for this continually evolving field, this book explores environmental factors and complexities affecting agricultural crops and animals].

Lampkin, N., (1992). Organic Farming. Farming Press, Ipswhich, England. [Scientific principles and practices of organic farming].

Magdoff, F., van Es, H., (2000). Building soils for better crops. Sustainable agriculture Network, Beltsville. [A compilation of major scientific reviews about the concepts that support practical soil organic matter management].

Pretty, J., (1995). Regenerating agriculture. Earthscan, London. [This book draws together empirical evidence from a diverse range of agroecological and community settings to show the positive impacts of sustainable practices].

Reinjtes, C., Haverkort, B., Waters-Bayer, A., (1992). Farming for the future. MacMillan, London. [This book examines the strategies and techniques of low-external-input and sustainable agriculture (LEISA) in the tropics].

Richards, P. (1985). Indigenous Agricultural Revolution. Westview Press, Boulder. [This book argues for less emphasis on teaching farmers how to farm and supplying improved inputs, and more on how to foster and support local adaptation and inventiveness].

Uphoff, Norman (ed.) 2002. Agroecological Innovations: Increasing Food Production with Participatory Development. Earthscan Publications Ltd., London. [The authors of the chapters in this book maintain that we would not be able to feed the world using conventional technology, that we need approaches that substitute human capital for manmade capital and external inputs].

Biographical Sketch

Dr Miguel Altieri leads the Agroecology Program at the University of California, Berkeley. His research group uses the concepts of agroecology to obtain a deep understanding of the nature of agroecosystems and the principles by which they function. Throughout their research and writings they have aided in the emergence of agroecology as the discipline that provides the basic ecological principles for how to study, design, and manage sustainable agroecosystems that are both productive and natural resource conserving, and that are also culturally-sensitive, socially-just and economically viable. In particular, their research has focused on the ways in which biodiversity can contribute to the design of pest-stable agroecosystems. Several studies concentrate on elucidating the effects of intercropping, cover cropping, weed management, and crop-field border vegetation manipulation on pest population density and damage and on the mechanisms enhancing biological control in diversified systems.

Their research has also extended into Latin America where the enhancement of biodiversity in agriculture can help the great mass of resource-poor farmers to achieve year-round food self-sufficiency, reduce their reliance on chemical inputs and develop agroecosystems that rebuild the production capacities of their small land holdings. Their approach has consisted of devising integrated farming systems emphasizing soil and water conservation, natural crop protection, and achievement of soil fertility and stable yields through integration of trees, animals, and crops. Much of this work is conducted through inter-institutional partnerships with NGOs, International Research Centers and Universities including networks such as SANE, ANGOC and CLADES, as well as international organizations such as UNDP and the CGIAR.