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Scaling up Agroecological Approaches for Food Sovereignty in Latin America

MIGUEL A. ALTIERI AND CLARA I. NICHOLLS

ABSTRACT *As the expansion of agroexports and biofuels continues unfolding in Latin America, the concepts of food sovereignty and agroecologically based production systems gain increasing attention. Miguel A. Altieri and Clara I. Nicholls suggest that the key importance will be the involvement of farmers directly in the formulation of the research agenda and on their active participation in the process of technological innovation and dissemination through models that focus on sharing experiences, strengthening local research and problem-solving capacities.*

KEYWORDS *agroecology; food sovereignty; sustainable agriculture*

Introduction

Both global and internal forces are challenging the ability of Latin America to feed itself while redefining the significance and the role of this important sector that has historically been of a dual nature. On the one hand, there is an export-oriented agricultural sector that makes a significant contribution to the national economies but at a high cost in terms of impacts on public health, ecosystem integrity, food quality, and in many cases disrupting traditional rural livelihoods, while accelerating indebtedness among thousands of farmers. The growing push towards industrialization and globalization with its emphasis on export crops such as transgenic soybeans for cattle feed for countries such as China, Europe, USA and others and the rapidly increasing demand for biofuel crops (sugar cane, maize, soybean, oil palm, eucalyptus, etc.) are increasingly reshaping the region's agriculture and food supply, with yet unknown economic, social and ecological impacts and risks.

On the other hand, there is a peasant or small farm sector that includes about 75 million people representing almost two-thirds of Latin America's total rural population. About 16 million peasant production units, averaging 1.8 ha covering 34.5 percent of the total cultivated land accounts for approximately 41 percent of the agricultural output for domestic consumption, including 51 percent of the maize, 77 percent of the beans and 61 percent of the potatoes consumed at a regional level (Ortega, 1986; Altieri, 1999). Many of these small farms are traditional farming systems that represent microcosms of community-based agriculture offering promising models for promoting

biodiversity, sustaining yield without agrochemicals and conserving ecological integrity while ensuring local food security.

As these trends unfold in the region, the concepts of food sovereignty and agroecologically based production systems have gained much attention. New approaches and technologies involving application of blended modern agricultural science and indigenous knowledge systems and spearheaded by thousands of farmers, NGOs and some government and academic institutions are enhancing food security while conserving natural resources, agrobiodiversity, and soil and water conservation throughout hundreds of rural communities in the region. The science of agroecology is defined as the application of ecological concepts and principles to the design and management of sustainable agroecosystems, with a minimal dependence on high agrochemical and energy inputs, emphasizing complex agricultural systems in which ecological interactions and synergisms between biological components provide mechanisms for the systems to sponsor their own soil fertility, productivity and crop protection (Gliessman, 1998). In addition to providing the scientific basis to sustainably enhance productivity, agroecology emphasizes the capability of local communities to innovate, evaluate and adapt themselves through farmer-to-farmer research and grassroots extension approaches. Agroecological approaches emphasize diversity, synergy, recycling and integration, and social processes that value community involvement, with human resource development as the cornerstone of any strategy aimed at increasing options for rural people and especially resource-poor farmers (Altieri, 1995).

Clearly, the above efforts reflect a growing awareness for the need to design a new agriculture that enhances the environment, preserves local cultures and associated biodiversity, and promotes food sovereignty and the multiple functions of small farm agriculture. The immediate challenge for our generation is to transform industrial agriculture by transitioning the world's food systems away from reliance on fossil fuels, develop an agriculture that is resilient to climatic variability and promote local forms of agriculture that ensure food sovereignty and the livelihoods of rural communities. In this paper, we analyse the fundamental reasons why the promotion of an agricultural development paradigm based on the revitalization of small farms is the only viable option to meet the region's food needs in this age of increasing oil prices and climate change. We also analyse the impacts that hundreds of agroecologically based projects throughout Latin America have had on the environment and food production and the requirements for the wide dissemination and adoption of agroecological principles by large numbers of farmers in order for agroecology to make a significant regional effect on the region's food sovereignty.

Small farmers are key for the region's food security

In Latin America, peasant production is responsible for producing, at the regional level, 51 percent of maize, 77 percent of beans and 61 percent of potatoes. In Brazil alone, there are about 4.8 million family farmers (about 85 percent of the total number of farmers) that occupy 30 percent of the total agricultural land of the country. Such family farms control about 33 percent of the area sown to maize, 61 percent of that under beans and 64 percent of that planted to cassava, thus producing 84 percent of the total cassava and 67 percent of all beans (Altieri, 2004). In Ecuador, the peasant sector occupies more than 50 percent of the area devoted to food crops such as maize, beans, barley and okra. In Mexico, peasants occupy at least 70 percent of the area assigned to maize and 60 percent of the area under beans. 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 are utilized by indigenous communities and 'ejidos' featuring integrated agriculture–forestry systems with production aimed at subsistence and local–regional markets (Toledo *et al.*, 1985).

Small farms are more productive and resource conserving than large-scale monocultures

Although conventional wisdom suggests that small family farms are backward and unproductive, research shows that small farms are much more productive than large farms if total output is considered rather than yield from a single crop. Small integrated farming systems that produce grains, fruits, vegetables, fodder and animal products out-produce yield per unit of single crops such as corn (monocultures) on large-scale farms. A large farm may produce more corn per hectare than a small farm in which the corn is grown as part of a polyculture that also includes beans, squash, potato and fodder. In polycultures 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 percent, because polycultures reduce losses due to weeds, insects and diseases and make a more efficient use of the available resources of water, light and nutrients. In Mexico, a 1.73 ha plot of land has to be planted with maize monoculture to produce as much food as 1 ha 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 (Gliessman, 1998).

The inverse relationship between farm size and output can be attributed to the more efficient use of land, water, biodiversity and other agricultural resources by small farmers. So in terms of converting inputs into outputs, society would be better off with small-scale farmers. Building strong rural economies in the Global South based on productive small-scale farming will allow the people of the South to remain with their families and will help to stem the tide of out-migration. And as the population continues to grow and the amount of farmland and water available to each person continues to shrink, a small farm structure may become central to feed the planet, especially when large-scale agriculture devotes itself to feed car tanks.

Traditional farms as models of sustainability

In Latin America, the persistence of more than three million agricultural hectares under ancient, traditional management in the form of raised fields, terraces, polycultures, agroforestry systems, etc., documents a successful indigenous sustainable agricultural strategy and comprises a tribute to the 'creativity' of traditional farmers (Altieri, 1999). An example is the chinampas in Mexico, which according to Sanders (1957) in the mid-1950s exhibited maize yields of 3.5–6.3 t ha^{-1}. At that time, these were the highest long-term yields achieved anywhere in Mexico. In comparison, average maize yields in the USA in 1955 were 2.6 t ha^{-1}, and did not pass the 4 t ha^{-1} mark until 1965. Each hectare of chinampa could produce enough food for 15–20 persons per year at modern subsistence levels. Recent research has indicated that each chinampero can work about three-quarters of a hectare of chinampa per year (Jimenez-Osornio and del Amo, 1986), meaning that each farmer can support 12–15 people.

Undoubtedly, the ensemble of traditional crop management practices used by many resource-poor farmers represent a rich resource for modern workers seeking to create novel agroecosystems well adapted to the local agroecological and socio-economic circumstances of peasants. Peasants use a diversity of techniques, many of which fit well to local conditions. The techniques tend to be knowledge-intensive rather than input-intensive, but clearly not all are effective or applicable; therefore modifications and adaptations may be necessary. The challenge is to maintain the foundations of such modifications grounded on peasants' rationale and knowledge.

Small farms are more resilient to climate change

In traditional agroecosystems, the prevalence of complex and diversified cropping systems is of key importance to the stability of peasant farming systems, allowing crops to reach acceptable productivity levels even in the midst of environmentally stressful conditions. In general, traditional agroecosystems are less vulnerable to

catastrophic loss because they grow a wide variety of crops and varieties in various spatial and temporal arrangements. Recent research suggests that many small farmers cope and even prepare for climate change, minimizing crop failure through increased use of drought-tolerant local varieties, water harvesting, mixed cropping, opportunistic weeding, agroforestry and a series of other traditional techniques (Browder, 1989).

Polycultures exhibit greater yield stability and less productivity declines during a drought than in the case of monocultures. Natarajan and Willey (1986) examined the effect of drought on enhanced yields with polycultures by manipulating water stress on intercrops of sorghum (*Sorghum bicolor*) and peanut (*Arachis* spp.), millet (*Panicum* spp.) and peanut, and sorghum and millet. All the intercrops overyielded consistently at five levels of moisture availability, ranging from 297 to 584 mm of water applied over the cropping season. Polycultures exhibited greater yield stability and less productivity declines during a drought.

Many farmers grow crops in agroforestry designs and shade tree cover protects crop plants against extremes in microclimate and soil moisture fluctuation. Farmers influence microclimate by retaining and planting trees, which reduce temperature, wind velocity, evaporation and direct exposure to sunlight and intercept hail and rain. Lin (2007) found that in coffee agroecosystems in Chiapas, Mexico temperature, humidity and solar radiation fluctuations increased significantly as shade cover decreased; thus she concluded that shade cover was directly related to the mitigation of variability in microclimate and soil moisture for the coffee crop.

Surveys conducted in hillsides after Hurricane Mitch in Central America showed that farmers using sustainable practices such as 'mucuna' cover crops, intercropping and agroforestry suffered less 'damage' than their conventional neighbours. The study spanning 360 communities and 24 departments in Nicaragua, Honduras and Guatemala showed that diversified plots had 20–40 percent more topsoil, greater soil moisture and less erosion and experienced lower economic losses than their conventional neighbours (Holt-Giménez, 2001). This points to the fact that a re-evaluation of indigenous technology can serve as a key source of information on adaptive capacity and resilient capabilities exhibited by small farms, features of strategic importance for world farmers to cope with climatic change. In addition, indigenous technologies often reflect a worldview and an understanding of our relationship to the natural world that is more realistic and more sustainable that those of our Western European heritage.

Many farmers maintain genetic diversity by growing, at the same time and in the same field, different cultivars of the same crops. In a worldwide survey of crop varietal diversity on farm involving 27 crops, Jarvis *et al.* (2007) found that considerable crop genetic diversity continues to be maintained on farm in the form of traditional crop varieties, especially of major staple crops. In most cases, farmers maintain diversity as in insurance to meet future environmental change or social and economic needs. Many researchers have concluded that variety richness enhances productivity and reduces yield variability.

Enhancing the productivity of small farming systems through agroecology

The failure of top-down development has become even more alarming as economic change, fuelled by capital and market penetration, is leading to an ecological breakdown that is starting to destroy the sustainability of traditional agriculture. After creating resource-conserving systems for centuries, traditional cultures in areas such as Mesoamerica and the Andes are now being undermined by external political and economic forces. Biodiversity is decreasing on farms, soil degradation is accelerating, community and social organization is breaking down, genetic resources are being eroded and traditions lost. Under this scenario and given commercial pressures and urban demands, many developers argue that the performance of subsistence agriculture is unsatisfactory, and that intensification of production is essential for the transition from subsistence to commercial production. Actually, the challenge is how to guide such

transition in a way that yields and incomes are increased without raising the debt of peasants and further exacerbating environmental degradation. We contend that this can be done by generating and promoting agroecologically based resource-conserving technologies, most of which are based on traditional farmers' knowledge, still intact in many rural regions despite the advance of industrial agriculture.

Ecological potential of some traditional systems

As the inability of the Green Revolution to improve production and farm incomes for the very poor became apparent, the new enthusiasm for ancient technologies spearheaded a quest in Latin America for affordable, productive and ecologically sound technologies that enhance small farm productivity while conserving resources. One of the early projects advocating this agroecological approach occurred in the mid-1970s when the then existing Mexico's Instituto Nacional de Investigaciones sobre Recursos Bióticos (INIREB) unveiled a plan to build 'chinampas' in the swampy region of Veracruz and Tabasco. Perfected by the Aztec inhabitants of the Valley of Mexico prior to the Spanish Conquest, chinampa agriculture involves the construction of raised farming beds in shallow lakes or marshes, and represents a self-sustaining system that has operated for centuries as one of the most intensive and productive ever devised by humans. A wide variety of staple crops, vegetables and flowers were mixed with an array of fruit from small trees and bushes. Abundant aquatic life in the canals provided valuable sources of protein for the local diet (Gliessman, 1998).

Threatened by the growth of Mexico city, chinampas have nearly vanished except in a few isolated areas. Though shrinking, this system still offers a promising model for other areas as it promotes biological diversity, thrives without chemical inputs and sustains year-round yields. This is how INIREB began its experiences with the transfer of the chinampa system to the lowland tropics of Mexico. Although implementation and adoption of chinampas in Tabasco met with mixed success, some critics feel that no market outlets were explored for the outputs produced by the community. The 'raised beds' of Tabasco (or camellones chontales) are still in full operation in the swamps of this region, and apparently the Chontal Indians have full control of them. They use traditional agriculture, and the new raised beds produce a great variety of products that produce income and food security to these 'swamp farmers'.

In the Andes, several institutions have engaged in programmes to restore abandoned terraces and build new ones in various regions of the country. In the Colca Valley of southern Perú, PRAVTIR (Programa de Acondicionamiento T erritorial y Vivienda Rural) sponsors terrace reconstruction by offering peasant communities low-interest loans or seeds and other inputs to restore large areas of abandoned terraces. The main advantage of using terraces is that it minimizes risk in times of frost and/or drought, reduces soil loss, amplifies cropping options because of the microclimate and hydraulic advantages of terraces, and improves crop yields. Yield data from new bench terraces showed a 43–65 percent yield increase in potatoes, maize and barley compared to yields of these crops grown on sloping fields. One of the main constraints of this technology is that it is highly labour-intensive, requiring about 350–500 workers day^{-1} ha^{-1}. Such demands, however, can be buffered when communities organize and share tasks (Altieri, 1995).

In Peru, researchers have uncovered remnants of thousands of hectares of 'ridged fields' in search of solutions to contemporary problems of high-altitude farming. A fascinating example is the revival of an ingenious system of raised fields that evolved on the high plains of the Peruvian Andes about 3,000 years ago. According to archaeological evidence, these Waru-Warus platforms of soil surrounded by ditches filled with water were able to produce bumper crops, despite floods, droughts and the killing frost common at altitudes of nearly 4,000 m (Denevan, 1995).

The combination of raised beds and canals has proven to have important temperature moderation effects, extending the growing season and leading to higher productivity on the Waru-Warus compared to chemically fertilized normal pampa

soils. In the Huatta district, reconstructed raised fields produced impressive harvest, exhibiting a sustained potato yield of 8–14 t ha^{-1} yr^{-1}. These figures contrast favourably with the average puno potato yields of 1–4 t ha^{-1} yr^{-1}. In Camjata, the potato fields reached 13 t^{-1} ha^{-1} yr^{-1} in Waru-Warus.

In Chiloe Island in Southern Chile, personnel of the Centro De Educacion y tecnologia (CET) are tapping the ethnobotanical knowledge of female elderly Huilliche Indians in an effort to slow genetic erosion and recover some of the original native potato germplasm. The goal is to make it available to contemporary impoverished farmers, desperately in need of locally adapted varieties that can produce without agrochemicals. After surveying several agroecosystems of Chiloe, CET technicians collected hundreds of samples of native potatoes still grown by indigenous farmers, and with this material and in collaboration with farmers they established community seed banks where more than 120 traditional varieties are grown year after year and are subjected to selection and seed enhancement. In this way, an *in-situ* conservation programme was initiated involving several farmers from various rural communities ensuring the active conservation and exchange of varieties among participating farmers. As more farmers became involved, this strategy allowed a continuous supply of seeds of value to resource-poor farmers for subsistence and also provided a repository of vital genetic diversity for future regional crop improvement programmes (Altieri, 2002).

Rural social movements, agroecology and food sovereignty

The development of sustainable agriculture will require significant structural changes in addition to technological innovation and farmer-to-farmer solidarity. Such change is impossible without social movements and their struggle to dismantle and transform the institutions and regulations that presently hold back sustainable agricultural development. For this reason, rural movements argue that a more radical transformation of agriculture is needed, one guided by the notion that ecological change in agriculture cannot be promoted without comparable changes in the social, political, cultural and economic arenas that conform and determine agriculture. The organized peasant- and indigenous-based agrarian movements (i.e. the Via Campesina) have long argued that farmers need land to produce food for their own communities and for their country and for this reason have advocated for genuine agrarian reforms to access and control land, water, agrobiodiversity, etc., which are of central importance for communities to be able to meet growing food demands. The Via Campesina believes that in order to protect livelihoods, jobs, people's food security and health as well as the environment, food production has to remain in the hands of small-scale sustainable farmers and cannot be left under the control of large agribusiness companies or supermarket chains. Only by changing the export-led, free-trade-based, industrial agriculture model of large farms can the downward spiral of poverty, low wages, rural–urban migration, hunger and environmental degradation be halted (Rosset, 2006). Social rural movements embrace the concept of food sovereignty as an alternative to the neo-liberal approach that puts its faith in an inequitable international trade to solve the world's food problem. Instead, it focuses on local autonomy, local markets, local production–consumption cycles, energy and technological sovereignty and farmer-to-farmer networks.

The achievement of food sovereignty implies major changes and requirements (Rosset, 2006; Rosset *et al.*, 2006):

- A shift in the role of subsidies away from supporting production, which results in food surpluses being dumped in poorer countries, towards a system of incentives offered to family farmers to keep them on the land and support vibrant rural economies, and subsidies that assist with soil conservation, the transition to sustainable farming practices, and local markets that pay fair prices to farmers.
- The ability to prioritize national–regional–local food security above the production of exports and dependence on imports.
- A shift away from hi-tech, intensive monoculture agriculture dependent on high levels of pesticide use, and transgenic crops.

- The rebuilding of rural economies and infrastructure, decreasing wealth discrepancies within rural areas and between rural and urban areas.
- Land reform and redistribution and/or enhanced access to land.
- A shift in the balance of power over the setting of food security priorities, away from Transnational Corporations (fostered by the trade rules of the WTO, NAFTA, etc.), towards national control.

It is imperative to realize that out-of-control trade liberalization is the key mechanism driving farmers off their land and the principal obstacle to local economic development and food sovereignty. It is also crucial to understand that a key enemy of farmers is low prices. And farm gate prices continue to drop even while consumer prices rise. This is because the main force dictating low prices to farmers is the same one that dictates high prices to consumers: the monopoly control that a few corporations exert over the food system. That means that breaking up these monopolies by enforcing antitrust laws nationally and globally is a key step towards ensuring that farmers can earn a living on the land and consumers can have access to affordable, nutritious and healthy food.

These movements understand that dismantling the industrial agrifoods complex and restoring local food systems must be accompanied by the construction of alternatives that suit the needs of small-scale producers and low-income consumers, and that oppose corporate control over production and consumption. Strategies aim at helping pro food sovereignty and sustainable agriculture farmer movements to document and share their alternatives among broad sectors of the rural and urban population to create political will and advance peasant-led food system alternatives.

Outlook and prospects

There is no question that small farmers in Latin America can produce much of the needed food for rural and urban communities, in the midst of climate change and burgeoning energy costs (Uphoff and Altieri, 1999; Pretty *et al.*, 2003). Whether the potential and spread of these thousands of local agroecological innovations is realized depends on several factors and actions. First, proposed agroecological strategies have to deliberately target the poor, and not only aim at increasing production and conserving natural resources, but also at creating employment and providing access to local inputs and output markets. New strategies must focus on the facilitation of farmer learning to become experts on agroecology and at capturing the opportunities in their diverse environments (Uphoff, 2002).

Second, researchers and rural development practitioners will need to translate general ecological principles and natural resource management concepts into practical advice directly relevant to the needs and circumstances of smallholders. A focus on resource-conserving technologies, which uses labour efficiently, and on diversified farming systems based on natural ecosystem processes will be essential (Altieri, 1995; Gliessman, 1998).

Any serious attempt at developing sustainable agricultural technologies must bring to bear local knowledge and skills on the research process (Richards, 1985). Particular emphasis must be given to involving farmers directly in the formulation of the research agenda and on their active participation in the process of technological innovation and dissemination through Campesino a Campesino models that focus on sharing experiences, strengthening local research and problem-solving capacities.

Third, major changes must be made in policies, institutions, and research and development to make sure that agroecological alternatives are adopted, made equitably and broadly accessible, and multiplied so that their full benefit for sustainable food security can be realized. Existing subsidies and policy incentives for conventional chemical approaches must be dismantled.

There is also a need to increase rural incomes through interventions other than enhancing yields, such as complementary marketing and processing activities. Therefore, equitable market opportunities should also be developed, emphasizing fair trade and local markets. The ultimate

challenge is to increase investment and research in agroecology and scale up projects that have already proven successful to thousands of other farmers.

Given the urgency of the problems affecting agriculture, coalitions that can rapidly foster sustainable agriculture among farmers, civil society organizations (including consumers) as well as relevant and committed research organizations are needed. Moving towards a more socially just, economically viable and environmentally sound agriculture will be the result of the coordinated action of emerging social movements in the rural sector in alliance with civil society organizations that are committed to support the goals of these farmers movements. The expectation is that through constant political pressure from organized farmers and members of civil society, politicians will be more responsive to develop and launch a policy conducive to enhance food sovereignty, to preserve the natural resource base, and to ensure social equity and economic viability.

'Greening' the green revolution will not be sufficient to reduce hunger and poverty and conserve biodiversity. If the root causes of hunger, poverty and inequity are not confronted head-on, tensions between socially equitable development and ecologically sound conservation are bound to accentuate. Organic farming systems that do not challenge the monocultural nature of plantations and rely on external inputs as well as foreign and expensive certification seals, or fair-trade systems destined only for agroexport, offer very little to small farmers that become dependent on external inputs and foreign and volatile markets. By keeping farmers dependent on an input substitution approach, fine-tuning of input use does little to move farmers towards the productive redesign of agroecosystems which would move them away from dependence on external inputs. Emphasising the exploitation of niche markets for the rich in the North, promotes agroexport schemes which do not prioritize food sovereignty but rather perpetuate dependence and hunger.

References

Altieri, Miguel A. (1995) *Agroecology: The science of sustainable agriculture*, Boulder: Westview Press.

Altieri, Miguel A. (1999) 'Applying Agroecology to Enhance Productivity of Peasant Farming Systems in Latin America', *Environment, Development and Sustainability* 1: 197–217.

Altieri, Miguel A. (2002) 'Agroecology: The science of natural resource management for poor farmers in marginal environments agriculture', *Ecosystems and Environment* 93: 1–24.

Altieri, Miguel A. (2004) 'Linking Ecologists and Traditional Farmers in the Search for Sustainable Agriculture', *Frontiers in Ecology and Environment* 2: 35–42.

Browder, John O. (1989) *Fragile Lands in Latin America: Strategies for sustainable development*, Boulder: Westview Press.

Denevan, William M. (1995) 'Prehistoric Agricultural Methods as Models for Sustainability', *Advanced Plant Pathology* 11: 21–43.

Gliessman, Stephen R. (1998) *Agroecology: Ecological process in sustainable agriculture*, Michigan: Ann Arbor Press.

Holt-Giménez, Eric (2001) 'Measuring Farms Agroecological Resistance to Hurricane Mitch', *LEISA* 17: 18–20.

Jarvis, Devra I., Christine Padoch and Harley David Cooper (2007) *Managing Biodiversity in Agricultural Ecosystems*, New York: Columbia University Press.

Jiménez-Osornio Juan and Silvia del Amo (1986) 'An Intensive Mexican Traditional Agroecosystem: The chinampa', Proceedings of the 6th International Scientific Conference IFOAM, Santa Cruz, CA.

Lin, Brenda B. (2007) 'Agroforestry Management as Adaptive Strategy against Potential Microclimate Extremes in Coffee Agriculture', *Agricultural and Forest Meteorology* 144: 85–94.

Natarajan, M. and R.W. Willey (1986) 'The Effects of Water Stress on Yield Advantages of Intercropping Systems', *Filed Crops Research* 13: 117–31.

Ortega, Emiliano (1986) *Peasant Agriculture in Latin America*, Santiago: Joint ECLAC/FAO Agriculture Division.

Pretty, Jules N., James I.L. Morrison and Rachel E. Hine (2003) 'Reducing Food Poverty by Increasing Agricultural Sustainability in Developing Countries', *Agriculture, Ecosystems and Environment* 95: 217–34.

Richards, Paul (1985) *Indigenous Agricultural Revolution*, Boulder: Westview Press.

Rosset, Peter M. (2006) *Food is Different: Why we must get the WTO out of agriculture*, (Global Issues), Nova Scotia: Fernwood Publishing.

Rosset, Peter M., Raj Patel and Michael Courville (2006) *Promised Land: Competing visions of agrarian reform*, Oakland: Food First Books.

Sanders, William T. (1957) 'Tierra y Agua: A study of the ecological factors in the development of Meso-American civilizations', PhD dissertation, Harvard University.

Toledo, M. Victor, Julia Carabias, Cristina Mapes and Carlos Toledo (1985) *Ecologia y Autosuficiencia Alimentaria*, Mexico City: Siglo Veintiuno Editores.

Uphoff, Norman (2002) *Agroecological Innovations: Increasing food production with participatory development*, London: Earthscan.

Uphoff, Norman and Miguel A. Altieri (1999) *Alternatives to Conventional Modern Agriculture for Meeting World Food Needs in the Next Century*, p 37, Ithaca, NY: Cornell International Institute for Food, Agriculture and Development.