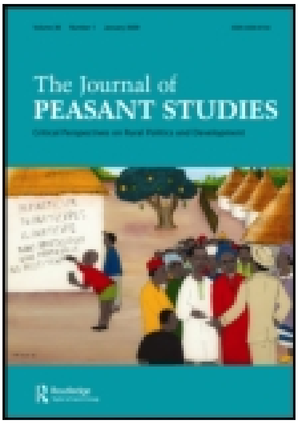

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The agroecological revolution in Latin America: rescuing nature, ensuring food sovereignty and empowering peasants

Miguel A. Altieri and Victor Manuel Toledo

This paper provides an overview of what we call 'agroecological revolution' in Latin America. As the expansion of agroexports and biofuels continues unfolding in Latin America and warming the planet, the concepts of food sovereignty and agroecology-based agricultural production gain increasing attention. New approaches and technologies involving the application of blended agroecological science and indigenous knowledge systems are being spearheaded by a significant number of peasants, NGOs and some government and academic institutions, and they are proving to enhance food security while conserving natural resources, and empowering local, regional and national peasant organizations and movements. An assessment of various grassroots initiatives in Latin America reveals that the application of the agroecological paradigm can bring significant environmental, economic and political benefits to small farmers and rural communities as well as urban populations in the region. The trajectory of the agroecological movements in Brazil, the Andean region, Mexico, Central America and Cuba and their potential to promote broad-based and sustainable agrarian and social change is briefly presented and examined. We argue that an emerging threefold 'agroecological revolution', namely, epistemological, technical and social, is creating new and unexpected changes directed at restoring local self-reliance, conserving and regenerating natural resource agrobiodiversity, producing healthy foods with low inputs, and empowering peasant organizations. These changes directly challenge neoliberal modernization policies based on agribusiness and agroexports while opening new political roads for Latin American agrarian societies.

Keywords: agroecology, peasant agriculture, food sovereignty, Latin America

Introduction

Agroecology is providing the scientific, methodological and technological basis for a new 'agrarian revolution' worldwide (Altieri 2009, Wezel and Soldat 2009, Wezel *et al*. 2009, Ferguson and Morales 2010). Agroecology-based production systems are biodiverse, resilient, energetically efficient, socially just and comprise the basis of an energy, productive and food sovereignty strategy (Altieri 1995, Gliessman 1998). Agroecological initiatives aim at transforming industrial agriculture partly by transitioning the existing food systems away from fossil fuel-based production largely for agroexport crops and biofuels towards an alternative agricultural

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paradigm that encourages local/national food production by small and family farmers based on local innovation, resources and solar energy. This implies access of peasants to land, seeds, water, credit and local markets, partly through the creation of supportive economic policies, financial incentives, market opportunities and agroecological technologies.

The key idea of agroecology is to go *beyond* alternative farming practices and to develop agroecosystems with minimal dependence on high agrochemical and energy inputs. Agroecology is both a science and a set of practices. As a science, agroecology consists of the 'application of ecological science to the study, design and management of sustainable agroecosystems' (Altieri 2002). This implies the diversification of farms in order to promote beneficial biological interactions and synergies among the components of the agroecosystem so that these may allow for the regeneration of soil fertility, and maintain productivity and crop protection (Altieri 2002). The core principles of agroecology include recycling nutrients and energy on the farm, rather than introducing external inputs; enhancing soil organic matter and soil biological activity; diversifying plant species and genetic resources in agroecosystems over time and space; integrating crops and livestock and optimizing interactions and productivity of the total farming system, rather than the yields of individual species (Gliessman 1998). Sustainability and resilience are achieved by enhancing diversity and complexity of farming systems via polycultures, rotations, agroforestry, use of native seeds and local breeds of livestock, encouraging natural enemies of pests, and using composts and green manure to enhance soil organic matter thus improving soil biological activity and water retention capacity.

There are alternative farming systems that are significantly different from agroecological approaches. For example, organic farming systems managed as monocultures that are in turn dependent on external biological and/or botanical (i.e. organic) inputs are not based on agroecological principles. This 'input substitution' approach essentially follows the same paradigm as conventional farming: that is, overcoming the limiting factor but this time with biological or organic inputs. Many of these 'alternative inputs' have become commodified, therefore farmers continue to be dependent on input suppliers, cooperative or corporate (Rosset and Altieri 1997). We argue that organic farming systems that do not challenge the monoculture nature of plantations and rely on external inputs as well as on foreign and expensive certification seals, or fair trade systems destined only for agro-export, offer little to small farmers who in turn become dependent on external inputs and foreign and volatile markets. Keeping farmers dependent on an input substitution approach, organic agriculture's fine-tuning of input use does little to move farmers toward the productive redesign of agricultural ecosystems that would move them away from dependence on external inputs. Niche (organic and/or fair trade) markets for the rich in the North exhibit the same problems of any agro-export scheme that does not prioritize food sovereignty (defined here as the right of people to produce, distribute and consume healthy food in and near their territory in an ecologically sustainable manner), often perpetuating dependence and at times hunger (Altieri 2009).

Agroecology is highly knowledge-intensive, and is based on techniques that are not delivered top-down but developed on the basis of farmers' knowledge and experimentation. For this reason agroecology emphasizes the capability of local communities to experiment, evaluate, and scale-up innovations 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 (Holt-Gimenez 2006). It is also in this context that agroecology promotes community-oriented approaches that look after the subsistence needs of its members, emphasizing self reliance, thus the usual presence of community grain banks. It is also an approach that very much privileges the local: providing for local markets that shorten the circuits of food production and consumption, and hence avoid the high energy needs of 'long-distance food'.

Agroecological systems are deeply rooted in the ecological rationale of traditional small-scale agriculture (Toledo 1990, Altieri 2004) and there are examples of a myriad of successful agricultural systems characterized by a tremendous diversity of domesticated crop and animal species maintained and enhanced by soil, water and biodiversity management regimes nourished by complex traditional knowledge systems (Toledo and Barrera-Bassols 2008). Such agricultural systems not only have fed much of the world population for centuries and continue to feed people in many parts of the planet, especially in developing countries, but also hold many of the potential answers to the production and natural resource conservation challenges affecting today's rural landscapes (Koohafkan and Altieri 2010).

In this overview paper we will briefly examine the fundamental reasons why the promotion of an agroecological paradigm based on the revitalization of small farms and social processes that value community involvement and empowerment is the only viable option to meet the region's food needs in this age of increasing oil prices and global climate change. We will also briefly look into the socio-ecological features and significance of peasant agriculture, and review the impacts that hundreds of agroecology-based projects in Cuba, Brazil, Mexico, Central America and the Andean region have had on the environment, food production and rural social movements. We end by making some reflections on the triple dimensions of the agroecological revolution, namely, cognitive, technological and social, which combined partly gave birth to new modes of communication between activism and science, a process that according to Martinez-Alier (2011) has reached global proportions as agroecology has been incorporated in the vision of *La Via Campesina*, today's most important transnational agrarian movement.

The context of the food crisis in the twenty-first century

Poverty reduction and food security are elusive goals for at least one billion people on the planet. The high levels of hunger, the inequity in the distribution of income, land, water, seeds and other resources, in addition to ecological degradation, are persistent and increasing problems at the global level. Despite billions of dollars invested in 'aid', 'development', and 'technological advances', the situation for these marginalized people has not improved, and in fact it is getting worse. There is no doubt that the increasing cost of energy, and the deterioration of the climate and global ecology are key factors that undermine the capacity of humankind to feed itself based on an industrial model of agriculture that is highly dependent on fossil fuel. The limits and vulnerability of the industrial model of agriculture are largely due to its low ecological diversity and narrow genetic base. Global food security could be considered the weak link between the ecological and economic crises affecting the planet. This became evident when the 'perfect storm' occurred in 2007–08 with the alarming rise in the cost of food that sent an additional 75 million people to the world's line of hungry people, especially in Sub-Saharan Africa and Asia. Oddly, there had been no drought – the usual cause of hunger – in those regions during that period and there was plenty of food in the markets. 'For no obvious reason the price of staple foods such as maize and rice nearly doubled in a few months ... There were food riots in more than 20 countries and governments had to ban food exports and subsidize staples heavily' (Vidal 2011; see also Holt-Gimenez and Patel 2009).

The explanation offered by FAO is that large farmers in the US, Brazil and other countries had taken millions of acres of land out of production to grow biofuels for vehicles, oil and fertilizer prices had risen steeply, the Chinese were shifting to a meat-based diet from a vegetarian diet, and climate change-linked droughts were affecting major crop-growing areas.[1] The same year (2008) that hunger expanded, cereal yields reached unprecedented levels, and the merchants of grain (e.g. Cargill, ADM) and corporate agricultural input and seed providers like Monsanto reaped enormous profits. A huge part of the problem is linked to the deregulation of international commodity markets, the privatization and/or elimination of grain markets in some countries, and recently the entry of speculative capital into the commodities market. The same banks, hedge funds and financiers whose speculation on the global money markets caused the sub-prime mortgage crisis are thought to be causing food prices to inflate. Between January 2006 and February 2008, financial investments pushed the prices of many food crops to higher values than those crops would have normally reached (Kaufman 2010). Contracts to buy and sell foods (cocoa, fruit juices, sugar, staples, meat and coffee) have been 'turned into "derivatives" that can be bought and sold among traders who have nothing to do with agriculture' (Hari 2010).

Food prices continue to rise beyond 2008 levels. They are now rising by up to 10 percent a year, and some predict that it is possible that they can increase by at least 40 percent in the next decade (Rosset 2009). Each time food prices increase, a significant number of family and peasant farmers are expelled from the market due to the low price that they receive for their products, and in part due to the high cost of inputs, principally fertilizers. Meanwhile the cost of food for consumers increases independently from what the price of wheat, corn or rice may be in the global commodity markets. In this way the deregulated market, privatization and free market treaties negatively affect both small farmers and consumers (Vidal 2011, Inter-American Dialogue 2011). The situation is aggravated by the systematic elimination of national production capacity by the promotion of agroexports and biofuels, partly stimulated by government subsidies. Another complicating factor is the land grabbing led by governments such as the Gulf States and China and wealthy investors who buy or lease land on an immense scale for intensive agriculture for offshore food and biofuel production.[2] In the end the new crisis is just a new face of the old rural crisis derived from the almost total control of the food system by transnational capital aided by neoliberal programs implemented by some governments (Rosset 2009).

We argue that that the threat of food insecurity is the direct result of the industrial model of agriculture characterized by large-scale monocultures of transgenic crops,

[1]FAO Initiative on Soaring Food Prices, available from: http://www.fao.org/isfp/about/en/ under global food price monitor [Accessed 10 April 2011].

[2]For more information see http://farmlandgrab.org/.

and that agrofuels exert pressures on increasingly degraded ecosystems further undermining nature's capacity to supply food, fiber and energy to a growing human population. The tragedy of industrial agriculture is that a growing human population depends on the ecological services provided by nature (e.g. climate balance, pollination, biological control, soil fertility) which intensive industrial agriculture increasingly pushes beyond the tipping point (Perfecto *et al*. 2009).

Traditional peasant agriculture: the roots of the agroecological proposal

Well into the first decade of the twenty-first century, there are 1.5 billion smallholders, family farmers and indigenous people on about 350 million small farms (ETC 2009). It may be extremely difficult to establish the actual numbers, but some estimate that approximately 50 percent of these peasants use resource-conserving farming systems –representing a testament to the remarkable resiliency of traditional agroecosystems in the face of continuous environmental and economic change – while contributing substantially to food security at local, regional and national levels (Toledo and Barrera-Bassols 2008). For these reasons most agroecologists acknowledge that traditional agroecosytems have the potential to bring solutions to many uncertainties facing humanity in a peak oil era of global climate change and financial crisis (Denevan 1995, Altieri 2004).

Although traditional agroecosystems dotting the rural landscapes of the region evolved in different contexts and geographical areas, such systems exhibit several common remarkable features (see Figure 1): (1) high levels of biodiversity that play key roles in regulating ecosystem functioning and also in providing ecosystem services of local and global significance; (2) ingenious systems and technologies of landscape, land and water resource management and conservation that can be used to improve management of agroecosystems; (3) diversified agricultural systems that contribute to local and national food and livelihood security; (4) agroecosystems that exhibit resiliency and robustness in coping with disturbance and change (human and environmental), minimizing risk in the midst of variability; (5) agroecosystems nurtured by traditional knowledge systems and farmers innovations and; technologies and (6) socio-cultural institutions regulated by strong cultural values and collective forms of social organization including normative arrangements for resource access and benefit sharing, value systems, rituals, etc. (Dewalt 1994, Koohafkan and Altieri 2010).

Food systems based on local circuits of peasant agroecological production and local consumption differ sharply from the industrial food chains. See Table 1 for a comparative perspective.

Many traditional small farmers tend to adopt a strategy of multiple use of natural resources, creating landscape mosaics of rich biological diversity (Toledo 1990). At the field level, one of the salient features of peasant farming systems is their high degree of plant diversity in the form of polycultures and/or agroforestry patterns. This strategy of minimizing risk by planting several species and varieties of crops stabilizes yields over the long term, promotes diet diversity and maximizes returns even with low levels of technology and limited resources. Such agro-diverse farms are endowed with nutrient-enriching plants, insect predators, pollinators, nitrogen-fixing and nitrogen-decomposing bacteria, and a variety of other organisms that perform various beneficial ecological functions. Traditional agroecosystems also contain populations of variable and adapted landraces as well as wild and weedy

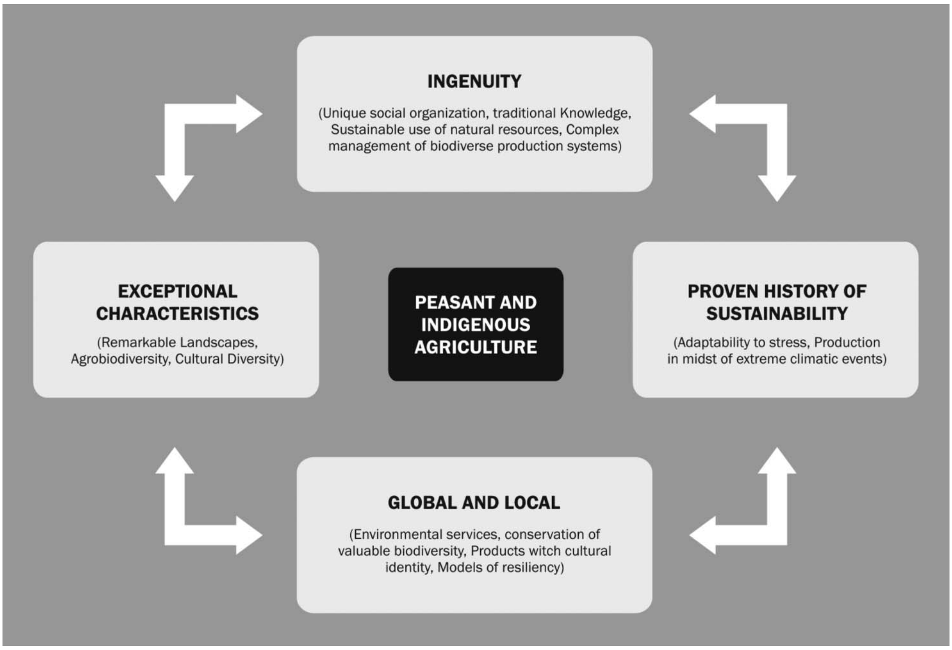

Figure 1. Remarkable features and services of peasant agriculture.
Source: Koohafkan and Altieri (2010).

Table 1. Some major differences between industrial and agroecology-based peasant food systems.

Industrial food systems	Agroecological peasant food systems
Agroexport crop and biofuel production, thousands of food miles, major emissions of greenhouse gases	Local, regional and/or national food production, local production and consumption circuits
Focus on less than 20 livestock and crop species	More than 40 livestock species and thousands of edible plants
Large-scale monocultures	Small-scale diversified farming systems
High yielding varieties, hybrids and transgenic crops	1.9 million land races and local crop varieties
High petroleum dependence and agrochemical inputs	Local resources, ecosystem services provided by biodiversity
Fertilizers for crop nutrition (to feed the plants)	Plant- and animal-derived organic matter to feed the soil
Top down, technicist extension schemes, corporate controlled scientific research	*Campesino a Campesino* (farmer to farmer), local innovations, socially-oriented horizontal exchanges via social movements
Narrow technological knowledge of parts	Holistic knowledge of nature, cosmovision
Inserted in simplified, degraded natural matrix non-conducive to conservation of wild species	Inserted in complex nature's matrix that provides ecological services to production systems (i.e. pollination, biological pest control, etc.)

Source: modified from Rosset *et al*. (2011) and ETC (2009).

relatives of crops. Such genetic diversity provides security to farmers against diseases, pests, droughts and other stresses and also allows farmers to exploit the full range of agroecosystems existing in each region that display differences in soil quality, altitude, slope, water availability, etc. Genetic diversity heightens stability of the cropping systems and enables farmers to exploit different microclimates and to derive multiple nutritional and other uses from the genetic variation among the species (Chang 1977, Clawson 1985).

At the landscape scale, diversification occurs by integrating multiple production systems to form mosaics of cropping systems with livestock, fallow fields, and agroforestry systems to create a highly diverse piece of agricultural land immersed in a matrix of primary or secondary forests (Perfecto *et al.* 2009). Such heterogeneity confers stability and resiliency to the systems.

Many traditional systems have stood the test of time, documenting a successful and resilient indigenous agricultural strategy and representing models of sustainability as they promote biodiversity, thrive without agrochemicals, and sustain year-round yields (Brokenshaw *et al.* 1980). For more than three decades Latin American agroecologists have argued that modern farming systems will necessarily have to be rooted in the ecological rationale of indigenous agriculture and that promising agricultural pathways, modeled after traditional farming systems, can help in the design of a biodiverse, sustainable, resilient and efficient agriculture.[3]

Latin America: food, peasants and agroecology

Both global and internal forces are challenging the ability of Latin America to feed itself while redefining the significance and the role of the agricultural sector, which has historically been of a dual nature. On the one side there is a specialized, competitive export-oriented agricultural sector which makes a significant contribution to the national economies, while bringing a variety of economic, environmental and social problems, including negative impacts on public health, ecosystem integrity, and food quality, and in many cases disrupting traditional rural livelihoods while accelerating indebtedness among thousands of farmers. The growing push toward industrialization and globalization with its emphasis on export crops such as transgenic soybeans for cattle feed for countries such as China, Europe, the USA and others, and the rapidly increasing demand for biofuel crops (e.g. sugar cane, maize, soybean, oil palm, eucalyptus) are increasingly reshaping the region's agriculture and food supply, with yet unknown economic, social and ecological impacts and risks (Pengue 2009).

On the other hand, there is a peasant or small farm sector with a population estimated at about 65 million, including 40–55 million indigenous people speaking about 725 languages (Toledo *et al.* 2010). Based on estimates a decade ago, these peasant small farming systems (average size of 1.8 hectares) produce 51 percent of the maize, 77 percent of the beans, and 61 percent of the potatoes consumed in the region (Ortega 1986, Altieri 1999). In Brazil alone, there are about 4.8 million family farmers (about 85 percent of the total number of agricultural producers) that occupy

[3]See publications by several Latin American agroecologists from CLADES (Centro Latino Americano de Desarrollo Sustenable (http://www.clades.cl/publica/publica_index.htm) and issues of LEISA Revista de Agroecología (http://www.agriculturesnetwork.org/magazines/latin-america).

30 percent of the total agricultural land of the country; they 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 88 percent of the total cassava and 67 percent of all beans (Altieri 1999). 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 cultivated to maize and 60 percent of the area under beans (Altieri 1999).

The Latin American peasantry is a highly heterogeneous group both culturally and ecologically, representing a gradient from subsistence farms based on local resources and agroecological techniques to semi-commercial and commercial farmers using agrochemical inputs and linked to national and international markets. Thus in one region it may be possible to find farmers still involved in a pure form of traditional agriculture all the way to peasants that have partially or totally adopted the agro-industrial mode of production. Those peasants in Figure 2 that have moved beyond 'stage 6Ag' in their conversion to the agroindustrial model have modified their system so profoundly (i.e. adopted specialized monocultures with hybrids of high energy and input dependence) that a reconversion to agroecological management may prove very difficult or impossible (when reaching stage '9Ag'). Most farmers situated between 0Ag and 5Ag incorporate varying elements of agroecological management, thus comprising a myriad of community-based agriculture systems that offer promising models for promoting biodiversity, sustaining yield without agrochemicals, and conserving ecological integrity while making a substantial contribution to domestic food security. As shown in Figure 3, agroecology can provide farmers, depending on their location along the modernization gradient (but not beyond stage 8Ag), with guidelines for the transition towards a more sustainable agriculture. Farmers in stages 0Ag and 1Ag can without much support from agroecology, using traditional indigenous technical knowledge transition directly to a sustainable rural society.

Despite much debate about the relationship between farm size and productivity (Dyer 1991, Dorward 1999), agroecologists have shown that small family farms are much more productive than large farms *if* total output is considered rather than yield

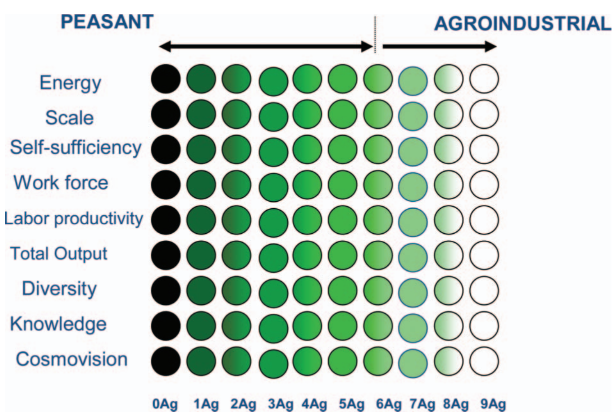

Figure 2. Characteristics of peasant agriculture in a gradient from traditional to agroindustrial modes of production.
Source: Toledo (1995).

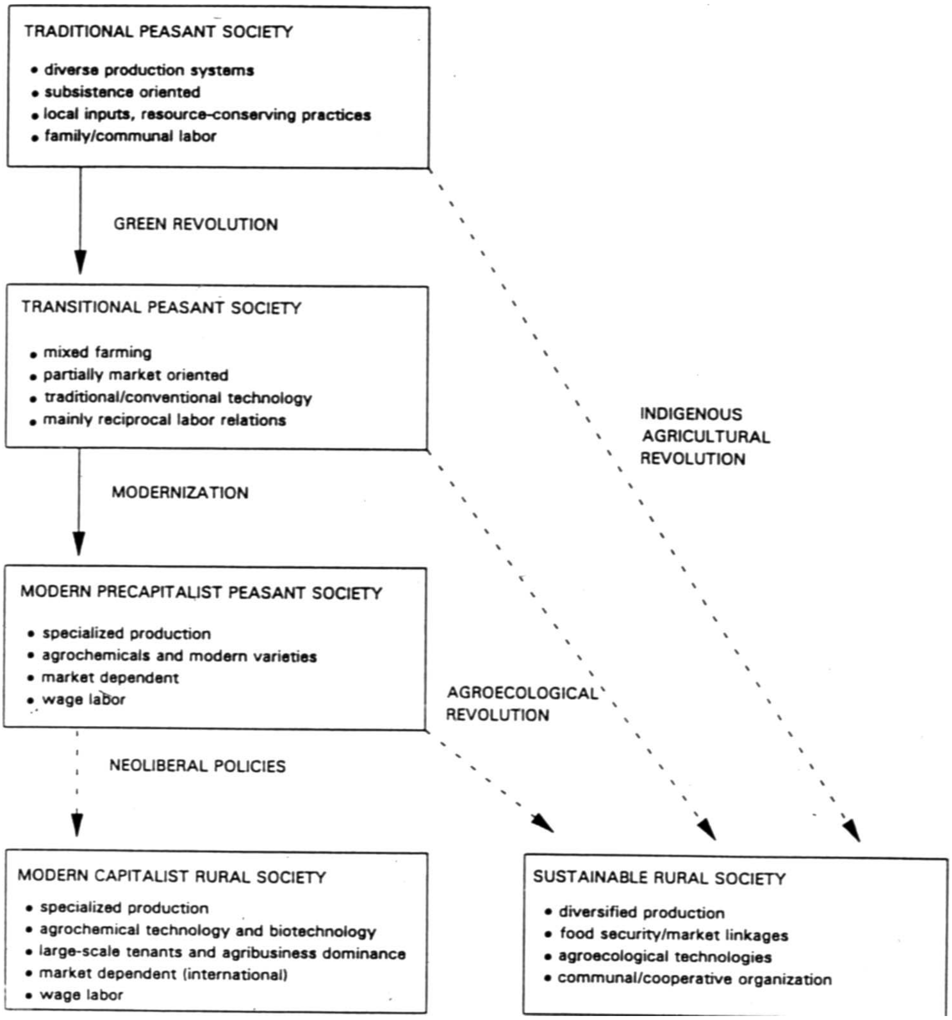

Figure 3. Pathways of peasant modernization and agroecological transitions towards a sustainable peasant rural society.

from a single crop (Rosset 1999, *Via Campesina* 2010). Integrated farming systems in which the small-scale farmer produces 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 percent to 60 percent, because polycultures reduce losses due to weeds, insects and diseases and make more efficient use of the available resources of water, light and nutrients (Beets 1982).

Studies in Mexico found that a 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 per ha of dry matter for plowing into the soil, compared with 2 t in a maize monoculture. In Brazil, polycultures containing 12,500 maize plants per ha and 150,000 bean plants per ha exhibited a yield advantage of 28 percent (Francis 1986). Increasing evidence shows that most peasant systems are productive despite their low use of chemical inputs. In the Amazon, the Kayapo yields are roughly 200 percent higher than colonist systems that use agrochemical technology (Hecht 1989). Generally, agricultural labor has a high return per unit of input. The energy return to labor expended in a typical highland Mayan maize farm is high enough to ensure continuation of the present system. To work a hectare of land, which normally yields 4,230,692 calories requires some 395 hours; thus, an hour's labor produces about 10,700 calories. A family of three adults and seven children eat about 4,830,000 calories of maize per year, thus current systems provide food security for a typical family of 5 or 7 people (Wilken 1987). Also in these systems, favorable rates of return between inputs and outputs in energy terms are realized. On Mexican hillsides, maize yields in hand-labor dependent swidden systems are about 1940 kg/ha, exhibiting an output/input ratio of 11:1. In Guatemala, similar systems yield about 1066 kg/ha of maize, with an energy efficiency ratio of 4.84. Yields per seed planted vary from 130 to 200. When animal traction is utilized, yields do not necessarily increase but the energy efficiency ratio drops to values ranging from 3.11 to 4.34. When fertilizers and other agrochemicals are introduced, yields can increase to levels of 5–7 t per ha, but energy ratios are highly inefficient at less than 2.5. In addition, most peasants are poor and generally cannot afford such inputs unless agrochemicals are subsidized (Pimentel and Pimentel 1979).

The practice of growing 'milpa' (maize many times combined with beans) is the foundation of food security in many Guatemalan rural communities. A study by Isakson (2009) shows that although most peasants are well aware of the potential to increase their returns from cash crops or other alternative economic activities, 99 percent of the households surveyed maintained that the practice was important to their family's food security. 'Milpa's contribution to the peasantry's food security represents much more than the calories it generates. It also provides a near guarantee that a family's basic sustenance needs will be met' (Isakson 2009, 764).

Peasant agriculture and climate change

Perhaps the most relevant aspect of the relationships between climate change and peasant agriculture is the realization that many small farmers cope with and even prepare for climate change, minimizing crop failure through increased use of drought tolerant local varieties, water harvesting, mixed cropping, agroforestry, soil conservation practices and a series of other traditional techniques (Altieri and Koohafkan 2008). Observations of agricultural performance after extreme climatic events in the last two decades have revealed that resiliency to climate disasters is closely linked to the level of on-farm biodiversity. A survey conducted in Central American hillsides after Hurricane Mitch showed that farmers using diversification practices such as cover crops, intercropping and agroforestry suffered less damage than their conventional monoculture neighbors. The survey, spearheaded by the *Campesino a Campesino* movement, mobilized 100 farmer-technician teams to carry out paired observations of specific agroecological indicators on 1,804 neighbouring sustainable and conventional farms. The study spanned 360 communities and

24 departments in Nicaragua, Honduras and Guatemala. It was found that sustainable plots had 20–40 percent more topsoil, greater soil moisture and less erosion and experienced lower economic losses than their conventional neighbours (Holt-Gimenez 2001). Similarly in Sotonusco, Chiapas, coffee systems exhibiting high levels of vegetational complexity and plant diversity suffered less damage from Hurricane Stan than more simplified coffee systems (Philpott *et al*. 2009). Forty days after Hurricane Ike hit Cuba in 2008, researchers conducted a farm survey in the Provinces of Holguin and Las Tunas and found that diversified farms exhibited losses of 50 percent compared to 90 or 100 percent in neighboring monocultures. Likewise agroecologically managed farms showed a faster productive recovery (80–90 percent 40 days after the hurricane) than monoculture farms (Machin-Sosa *et al*. 2010). All three studies emphasize the importance of enhancing plant diversity and complexity in farming systems to reduce vulnerability to extreme climatic events. The fact that many peasants commonly manage polycultures and/or agroforestry systems points at the need to re-evaluate indigenous technology as a key source of information on adaptive capacity centered on the selective, experimental and resilient capabilities of farmers in dealing with climatic change. Understanding the agroecological features of traditional agroecosystems can serve as the foundation for the design of climate change resilient agricultural systems (Altieri and Koohafkan 2008).

Undoubtedly, the myriad of traditional systems still existing in Latin America comprise a globally important ingenious agricultural heritage that reflects the value of the diversity of agricultural systems adapted to different environments and tells a fascinating story of the ability and ingenuity of humans to adjust and adapt to the vagaries of a changing physical and material environment from generation to generation. These systems comprise a Neolithic legacy of considerable importance, yet modernization constantly threatens the sustainability of this inheritance. Despite their ecological and cultural significance and the wealth and breadth of accumulated knowledge and experience in the management and use of resources that these systems represent, very few efforts are underway to protect and conserve such ancient farming systems (Koohafkan and Altieri 2010).

The five poles of agroecological innovation in Latin America

Traditional agriculture has constituted the cultural and historical platform for the development, multiplication and expansion of agroecological projects. Since the early 1980s, hundreds of agroecology-based projects have been promoted by NGOs and later by farmers organizations which incorporate elements of both traditional knowledge and modern agricultural science (Altieri *et al*. 1998, Uphoff 2002). In the early twentieth century the realization of the ecological and social services provided by indigenous farming systems and the contribution of peasant agriculture to food security in the midst of scenarios of global climate change, economic and energy crisis provided major impetus to the concepts of food sovereignty and agroecology-based production systems (de Schutter 2010).

The expansion of agroecology in Latin America has initiated an interesting process of cognitive, technological and socio-political innovation, intimately linked to the new political scenarios such as the emergence of progressive governments and resistance movements of peasants and indigenous people. Thus the new agroecological scientific and technological paradigm is being built in constant reciprocity with social movements and political processes. The technological dimension of the agroecological revolution emerges from the fact that contrary to Green Revolution approaches that emphasized seed-chemical packages and 'magic bullet' recipes, agroecology works with principles that take multiple technological forms according to the local socio-economic needs of farmers and their biophysical circumstances. Agroecological innovations are born *in situ* with the participation of farmers in a horizontal (not vertical) manner and technologies are not standardized but rather flexible and respond and adapt to each particular situation.

There are many epistemological innovations that have characterized the agroecological revolution in the region (Ruiz-Rosado 2006, Toledo 1995):

(a) agroecology integrates natural and social processes joining political ecology, ecological economics and ethnoecology among the hybrid disciplines;
(b) agroecology uses a holistic approach therefore it has long been considered as a transdiscipline as it integrates the advances and methods of several other fields of knowledge around the concept of the agroecosystem viewed as a socio-ecological system;
(c) agroecology is not neutral and is self-reflexive, giving rise to a critique of the conventional agricultural paradigm;
(d) it recognizes and values local wisdom and traditions, creating a dialogue with local actors via participatory research that leads to a constant creation of new knowledge;
(e) agroecology adopts a long-term vision that sharply contrasts with the short-term and atomistic view of conventional agronomy; and
(f) agroecology is a science that carries an ecological and social ethics with a research agenda of creating nature friendly and socially just production systems.

There are five geographical areas in Latin America where the agroecological revolution has taken hold, and depending on the maturity of the advances they may be considered poles of technological, cognitive and/or social innovation.

Brazil's agroecological awakening

Perhaps no other country has experienced a more dramatic expansion of agroecology than Brazil, which in the 1980s started building upon the work of J. Lutzenberger (*Fundamentos Ecologicos da Agricultura* 1981), who nourished a philosophical and alternative vision of agriculture, and M. Primavesi's (1984) ecological management of soils, in which she developed a detailed theory of agroecosystem health based on soil management (Khatounian 2002). The AS-PTA (Assessoria e Serviços a Projetos em Agricultura Alternativa (AS-PTA)) network played a major role in disseminating agroecological information among NGOs, farmer's organizations and agriculture students throughout the country.[4] In the following decades agroecological advances in Brazil were linked to three main processes: the training of a new generation of Brazilian agroecologists, many of whom became professors and researchers in public universities and research-extension centers; the re-orientation of the movement of family agriculture towards agroecology; and the arrival of agroecologists to key state and federal government

[4]See www.aspta.org.br [Accessed 10 February 2011].

positions wherein they generated hundreds of agroecological development initiatives (VonderWeid 1994, Petersen 2009).

Many public universities have incorporated agroecology into the agronomic curricula and state and federal organizations (i.e. CNPq, Consejo Nacional de Desarrollo Científico y Tecnológico, and CAPES, Coordenação de Aperfeiçoamento de Pessoal de Nível Superior) fund educational and research projects in the area of sustainable agriculture. The *Ministerio do Desenvolvimento Rural* (MDA) has also played a major role in supporting education and research projects, but most importantly has created important instruments for family farmers to have access to know-how, credit, markets, etc. The creation of the *Associacao Brasileira de Agroecologia*[5] has been key to bringing together small farmers, researchers and NGO technicians to discuss advances and strategies in their six national congresses and hundreds of state-level congresses and meetings that go on annually in Brazil. The launching in 2006 of *Articulacao Nacional de Agroecologia* (ANA) was key as ANA acts as a strategic instrument for the coordination of efforts among farmers' organizations, academic institutions and people from the NGO spheres.[6]

Perhaps of most significance is the ideological encounter between agroecology and the main rural political organizations of Brazil such as *la Confederacao Nacional dos Trabalhadores na Agricultura* (CONTAG), *la Federacao dos Trabalhadores na Agricultura Familiar* (FETRAF) and the Movimento dos Trabalhadores Ruraes Sem Terra (MST). These organizations have historically struggled to put an end to the enormous agrarian injustices in Brazil where 1.6 percent of landowners possess 47 percent of the land and where 3 percent of the rural population owns 66 percent of the arable land. The MST has adopted agroecology and actively promotes it among its 1.5 million members. In 2005, the MST's National Congress (with 11,000 participants) adopted agroecology as the technological basis of small scale farming and since then has tirelessly implemented educational processes, has created 12 Agroecology Autonomous Schools, in addition to the Centro 'Chico Mendez' created in 2004, and in 2005 created the *Escuela Latinoamericana de Agroecología* in Paraná. There are four main reasons why agroecology has been embraced by the social rural movements:

(a) agroecology is socially activating as its diffusion requires constant farmers participation;
(b) it is a culturally acceptable approach as it builds upon traditional knowledge and promotes a dialogue of wisdoms with more western scientific approaches;
(c) it promotes economically viable techniques by emphasizing use of indigenous knowledge, agrobiodiversity and local resources, avoiding dependence on external inputs;
(d) agroecology is ecologically sound as it does not attempt to modify the existing production systems, but rather tries to optimize their performance promoting diversity, synergy and efficiency.

Even the Empresa Brasileira de Pesquisa Agropecuaria (EMBRAPA), which represents the public agricultural research apparatus, has programs on agroecology

[5]For more information, see http://www.aba-agroecologia.org.br/aba2/ [Accessed 10 February 2011].
[6]For more information, see http://www.agroecologia.org.br/ [Accessed 10 February 2011].

promoted by scientists linked to ABA, ANA and social movements and that use agroecology as a research framework (Petersen 2009). EMBRAPA's agroecology program emphasizes agroecosystems and agrobiodiversity in family farms, using systemic, interdisciplinary and participatory approaches to better integrate farmers' knowledge. Agroecology is seen both as an emerging science and as a field of transdisciplinary knowledge, influenced by social, agrarian and natural sciences, especially applied ecology. EMBRAPA also uses agroecology as the foundation to promote sustainable agriculture and rural development programs in the country.[7]

Cuba: a post peak-oil agricultural model

During the last two decades Cuba has experimented with a process of social, technological, energy and food system transformation as a response to the crisis prompted by the collapse of the Soviet Union. Since the beginning of the Revolution and especially since the 'Special Period'[8] the Cuban people have been involved in attempts to achieve 'food sovereignty' in the midst of an inhumane US trade embargo, and after the collapse of imports of petroleum, agrochemicals and farm machinery from the Soviet bloc. Top Cuban agricultural researchers reported in the book *Sustainable agriculture and resistance: transforming food production in Cuba* (Funes *et al*. 2002) how Cuba was unable to import either food or materials needed for conventional agriculture and thus turned inward to self-reliance. Sustainable agriculture, organic farming, urban gardens, smaller farms, animal traction and biological pest control all became part of the new Cuban agriculture (for a detailed history of this process see Machin-Sosa *et al*. 2010, Rosset *et al*. 2011).

The growth of the agroecological movement can be partly linked to the training, extension and research activities of the *Asociacion Cubana de Tecnicos Agricolas y Forestales* (ACTAF) in its goals to promote agroecology throughout the island. But what constitutes the soul of the Cuban agroecological revolution are the efforts of about 100,000 families – almost half the population of independent small farmers in Cuba – who are members of ANAP (National Association of Small Farmers). These peasants practice agroecological diversification methods on their farms, thereby producing much more food per hectare than any commercial, industrial agriculture farm. These family farmers, many of whom are part of the *Campesino a Campesino* (farmer-to-farmer) movement, produce over 65 percent of the country's food, on only 25 percent of the land (Rosset *et al*. 2011). The recent study of Machin-Sosa *et al*. 2010 revealed that in less than a decade the active participation of small farmers in the process of technological innovation and dissemination through farmer-to-farmer models that focus on sharing experiences, strengthening local research and problem-solving capacities has produced a major impact.

It is estimated that depending on the region, agroecological practices are used in 46–72 percent of the peasant farms producing about 60 percent of the vegetables, maize, beans, fruits and pork meat consumed on the island. Small farmers using

[7]Marco Referencial em Agroecologia, available from: http://www.embrapa.br/publicacoes/transferencia/marco_ref.pdf/view [Accessed 10 February 2011].

[8]'After facing one of the hardest crises in its history, the Cuban economy, surrounded by an environment that is hostile to socialist forms of production, has managed to develop during the so called "Special Period", [which started in 1991] and is characterized by a strong process of redesign of the economic policy, an industrial re-conversion and structural transformation of production management' (Banco Central de Cuba 2001).

agroecological methods obtain yields per hectare sufficient to feed about 15–20 people per year with energy efficiencies of no less than 15 (Funes 2009). Evaluations conducted in Holguin and Las Tunas after Hurricane Ike in 2008 revealed that although somewhat affected, agroecological farms suffered a damage level of 50 percent compared to the monocultures that reached levels of 90–100 percent. It was also observed that agroecological farms recovered faster and about 80 percent of the farms resumed production 40 days after the hurricane (Rosset *et al.* 2011).

Given the economic, energy and climatic conditions facing the island, the Cuban peasantry supported by agroecological strategies exhibits today the highest indexes of productivity, sustainability and resiliency in the region. Agroecology, as being promoted by *Campesino a Campesino* movement, is proving to be the most efficient, cheap and stable way of producing food per unit of land, input and labor. As this process advances, more small farmers join this agroecological revolution (the government now is giving up to 13.5 hectares to families interested in becoming farmers: so far there are 100,000 petitions for this land), and the goal is to reach 1.5 million hectares under agroecological management, enough to make the island food sovereign (Funes 2009; see also Rosset *et al.* 2011).

Cuba's achievements in urban agriculture have also grown and are truly remarkable: 383,000 urban farms, covering 50 thousand hectares of otherwise unused land and producing more than 1.5 million tons of vegetables (top urban farms reach a yearly yield of 20 kgs per square meter of edible plant material using no synthetic chemicals) enough to supply 40–60 percent or more of all the fresh vegetables in cities such as Havana, Villa Clara and others (Funes *et al.* 2009). No other country in the world has achieved this level of success with a form of agriculture that reduces food miles, energy and input use, and effectively closes local production and consumption cycles (Koont 2009).

Central America: the *campesino-to-campesino* movement

The first peasant-driven process of technological innovation in contemporary agroecology in the region took place in the north of Central America in the late 1980s. The story begins in the highlands of Guatemala where Kaqchikel farmers visited Mexican farmers in Tlaxcala (Vicente Guerrero), where they had created a school of soil and water conservation. The Guatemalan farmers used parables, stories, and humor to present agricultural improvements to their Mexican *compadres* as a logical outcome of clear thinking and compassion; love of farming, of family, of nature, and of community. Rather than try to convince the Mexicans of their innovations, they insisted they experiment with the new ideas on a small scale first to see how well they worked. And they saw themselves as students, respecting the Mexicans' deep, lifelong knowledge of their own particular land and climate. All they asked in return was that the Mexicans turn around and share their new knowledge with others – which they did. This exchange was typical of a grassroots movement called *Campesino a Campesino* (CAC), or Farmer-to-Farmer, which has grown up in southern Mexico and war-torn Central America over the last three decades (Holt-Gimenez 2006, Hocdé *et al.* 2000).

In the midst of the Sandinista epoch in Nicaragua the CAC technologies were introduced in the *Unión Nacional de Agricultores y Ganaderos de Nicaragua* (ANAG), the main government controlled organization of large- and medium-sized farmers. Despite the fact that UNAG was dominated by the principles of conventional agriculture, agroecological principles and methods ware slowly introduced through the work of *promotores* who organized and led workshops. By 1995, about 300 agroecological *promotores* had been able to influence about 3,000 families. In 2000, about 1,500 *promotores* were working with no less than one third of the Nicaraguan peasant families (Holt-Gimenez 2006).

Across Nicaragua, Guatemala and Honduras, a key element in the CAC methodology is the role of the *promotor campesino* who is a fellow farmer successfully using a given alternative on his/her own farm and that therefore can train and stimulate other farmers based on his/her own experience. These promoters engage in a process of diffusion of agroecological knowledge without the presence of researchers or extension workers. Eric Holt-Giménez (2006) has extensively documented the Mesoamerican experiences with CAC as a methodology for promoting agroecological farming practices, which he calls 'peasant pedagogy' (Bunch 1990, Holt-Giménez 2006, Machín-Sosa *et al*. 2010).

Today it is estimated that about 10,000 families in Nicaragua, Honduras and Guatemala practice the *Campesino a Campesino* method. It was via the CAC method that soil conservation practices were introduced in Honduras, and hillside farmers adopting the various techniques tripled or quadrupled their yields from 400 kilograms per hectare to 1,200–1,600 kilograms. This tripling in per-hectare grain production has ensured that the 1,200 families that participated in the program have ample grain supplies for the ensuing year. The adoption of velvet bean (*Mucuna pruriens*), which can fix up to 150 kg of nitrogen per ha as well as produce 35 tonnes of organic matter per year, helped tripled maize yields to 2500 kg/ha. Labor requirements for weeding were cut by 75 percent and herbicides eliminated entirely. The focus on village extension workers was not only more efficient and less costly than using professional extension technicians, it also helped to build local capacity and provide crucial leadership experience (Bunch 1990). Taking advantage of well-established farmer-to-farmer networks such as the *Campesino a Campesino* movement in Nicaragua and elsewhere, the spread of this simple technology has occurred rapidly. In just one year, more than 1,000 peasants recovered degraded land in the Nicaraguan San Juan watershed (Holt-Gimenez 2006). Economic analyses of these projects indicate that farmers adopting cover cropping have lowered their utilization of chemical fertilizers (from 1,900 kg/ha to 400 kg/ha) while increasing yields from 700kg to 2,000kg/ha, with production costs about 22 percent lower than those of farmers using chemical fertilizers and monocultures (Buckles *et al*. 1998).

The Andean region: agroecology and cosmovision

The huge presence of a peasantry of deep historical roots, a pre-hispanic agricultural legacy, and an active level of political resistance by indigenous movements make the Andean region of Perú, Ecuador and Bolivia an excellent setting for the development of agroecology. For at least two decades, these countries have witnessed an increasing process of social unrest alongside a surprising capacity for self–organization. The indigenous mobilization that paralyzed the roads of Ecuador in 1990 and then again in 1994 when the congress approved a type of market-based land reform, and the march against the government in 2000, prove that the indigenous movement is the main force slowing neoliberal policies and supporting progressive governments such as those of the Correa and Morales administrations. These rural movements that operate via decentralized networks find their cells in the communities, cooperatives and farmers organizations that have found in agroecology a new paradigm for the re-creation of native Andean agriculture.

Since the 1980s a significant group of researchers, technicians and promoters from a number of NGOs and academic institutions have been promoting the re-creation of Andean peasant agriculture, maintaining the traditional cosmovision but using scientific elements of agroecology (Chavez 1989, Tapia 2002). In many ways Andean agriculture offers huge potential to develop a successful agroecological strategy. The evolution of agrarian technology in the Central Andes has produced extensive knowledge about using the Andean environment (Brush 1982). This knowledge affected the division of the Andean environment into altitudinally arranged agroclimatic belts, each characterized by specific field and crop rotation practices, terraces and irrigation systems, and the selection of many animals, crops, and crop varieties. The most important cultural adaptation to these environmental constraints has been the development of farming systems and technologies designed to yield an adequate diet with local resources while avoiding soil erosion. The highlands of Peru contain more than 600,000 hectares of terraces, mostly constructed in prehistoric times. These staircase farms, built up steep mountain slopes with stone retaining walls, contributed vast amounts of food to the *Incas*. They provided tillable land, controlled erosion, and protected crops during freezing nights. Many were irrigated with water carried long distances through stone canals (Tapia 2000). Today, as in the distant past, the chief crops on these terraces are native tubers, such as potatoes, chenopods, oca, and ulluco, all valuable sources of genetic diversity for humankind.

Many groups such as AGRUCO (*Agroecologia Universidad Cochabamba*) in Bolivia and PRATEC (*Proyecto Andino de Tecnologías Campesinas*) in Peru as well as several researchers have studied pre-Columbian technologies 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 archeological 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 meters (Erickson and Chandler 1989). In 1984 several NGOs and state agencies created the *Proyecto Interinstitucional de Rehabilitacion de Waru-Warus* (PIWA) to assist local farmers in reconstructing ancient systems. 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. Clearly, raised beds require strong social cohesion for the cooperative work needed on beds and canals. For the construction of the fields, NGOs organized labor at the individual, family, multi-family, and communal levels. Elsewhere in Peru, several NGOs in partnership with local government agencies engaged in programs to restore abandoned ancient terraces leading to efforts that contributed to the food security of thousands of people inhabiting marginal lands (Sanchez 1994).

Also in close relationship with an agroecology rooted in Andean culture new small farmer associations have emerged such as AOPEB (*Asociación de Organizaciones de Productores Ecológicos de Bolivia*), founded in 1991 and composed of 75 organizations and about 70,000 families.[9] In Peru, ANPE (*Asociación de Productores*

[9]For more information see http://www.aopeb.org/.

Ecológicos) has 12,000 members from 22 different regions of the country.[10] Both organizations have gained support from urban consumers and their political weight is becoming noticeable. Partly as a result of pressures from the agroecological movement, president Evo Morales situated agroecology as one of the four central goals of his mandate and promoted Law 3525, which regulates agro-silvo-pastoral production in Bolivia.

Sustainable rural communities in Mexico

Within the Latin American context, Mexico is in agrarian terms a unique country. The revolution at the beginning of the twentieth century (1910–1917) generated the first agrarian reform on the continent, leaving in the hands of the peasant and indigenous communities a great part of the land, forests and native germplasm. The dismantling of about 11,000 large *latifundios* and *haciendas* (on the eve of the revolution, two percent of the rural population controlled 65 percent of the land) took about six decades. Today, the so-called social property includes more than 100 million hectares distributed among two kinds of social owners: *ejidos,* which constitute peasant family nuclei favored by the redistribution of land, and *comunidades*, primarily old indigenous communities that are re-established and recognized. In both cases property is of a social nature, regimented by rules of access, possession and transmission based on the community and equitable use of land. These conditions have prevailed despite the counter agrarian reform implemented by C. Salinas de Gortari in 1992, directed at privatizing the social property and making it available to private enterprises. This fact, among other things, provoked the neo-Zapatista uprising in Chiapas.

According to the last agrarian census, in 1991 there were in Mexico about 4.58 million rural property owners of which 66 percent were peasant families controlling 103 million hectares, and 30 percent were private owners with about 70 million hectares. It is important to recognize this agrarian panorama in order to understand the social, cultural and political significance of agroecological projects in Mexico. The other important aspect to be considered is cultural, given that Mexico gave birth to one of the most ancient and vigorous civilizations: Mesoamerica. In this region, where the domestication of maize and one hundred other plant species took place over a period of several thousand years, a number of societies bloomed in practically each main area of Central and South Mexico. Today, the Mesoamerican indigenous population includes about 12 million people distributed across 26 regions occupying the majority of habitats in Mexico. The peasant sector that still uses indigenous languages controls an area estimated at 28 million hectares (Boege 2008). The most biologically rich areas (*selvas*,[11] forests) and the great majority of traditional agriculture with its unique germpasm are located in this area. More than 7,000 *ejidos* possess 70–80 percent of the forests and *selvas* (Toledo 2001). Together with China and New Guinea, Mexico is the country with the highest percentage of forest and *selvas* under communal custody and management. In the last two decades, this fact has motivated the creation of innumerable ecological reforestation projects. Peasant and indigenous territories contain the main sources of water, biodiversity and genetic resources in the country, constituting a unique biocultural wealth (Toledo *et al*. 2010).

[10]For more information see http://www.anpeperu.org/.
[11]A *selva* is a very biodiverse tropical forest.

The Mexican revolution attained two immense advances: the re-peasantization as a result of the dismantling of *latifundia*, and the rescue and re-invention of the mesoamerican matrix that again provided indigenous people with access to land through the recognition of their ancestral territories. Justice was made by re-valuating the small farm property (average size of the family plot is nine hectares, with rights to use communal lands of about 25 hectares) thus revaluing a culture that emerged from the interaction of social groups with natural resources some 9,000 years ago (Toledo and Barrera-Bassols 2008).

In the case of Mexico, agroecological experiences are not reduced to agriculture but rather involve socio-ecological systems of natural resource management, including forests, the restoration of degraded lands and the conservation of agrobiodiversity. During the last three decades numerous communities have started to recover control over their forest lands and are engaged in the ecological production of a variety of timber and non-timber products. Among these the programs of the *Unión Nacional de Forestería Comunitaria* (UNOFOC) that promote ecological forest management, about 550 communities and *ejidos* stand out.[12]

In the Mixteca region of Oaxaca there are a series of initiatives that started 20 years ago led by indigenous NGOs such as *Centro de Desarrollo Integral Campesino de la Mixteca* (CEDICAM) whose main goal is to restore watershed through reforestation, soil and water conservation and crop diversification for food security. CEDICAM has promoted dozens of organized farmers groups in nine communities to reforest large areas and to build contour ditches on hillsides above threatened springs and shallow wells to recharge the aquifers that feed these drinking water sources.

The groups led by CEDICAM promoters are building ditches for soil conservation or reforesting with pines (*Pinus oaxacana*) and native species. In El Progreso, about 80 percent of the total community participates and they have restored 100 hectares of degraded land. In Buenavista Tilantongo the community reforested 10 hectares. In El Carmen farmers started reforesting 11 years ago, planting 40,000 trees in 2003 and 70,000 in 2004. It is estimated that a one-lineal-meter, 60cm by 60cm, ditch can capture up to 360 liters of water from one rainfall event. A long 100-meter ditch can potentially capture 36,000 liters, which ideally would infiltrate deep into the soil and thus recharge the aquifers, allowing local farmers to meet part of their water requirements for household and agricultural use.[13]

At the global level, Mexico occupies the fifth place in coffee production, most of which is done by 200,000 small farmers occupying around 770,000 hectares. Most coffee producers are indigenous people belonging to about 28 different ethnic groups (Moguel and Toledo 1999). These producers maintain complex coffee agroforests where in addition to coffee they manage a great number of useful species, drastically differing from industrial open sun coffee plantations subsidized by agrochemicals and are prone to soil erosion. The great majority of coffee producers are organized in cooperatives that belong to regional and ultimately to national organizations such as the *Coordinadora Nacional de Organizaciones Cafetaleras* (CNOC). Mexico is number one in the world in the production of certified organic coffee. It is estimated that about 300,000 hectares are under multistrata 'coffee gardens' of which 80

[12]See www.unofocac.pbworks.com. Ecological forest management schemes of these communities are certified by the Forest Stewardship Council.

[13]'Jesús León Santos, Mexico, Sustainable Development', The Goldman Prize, available from: http://www.goldmanprize.org/2008/northamerica [Accessed 10 February 2010].

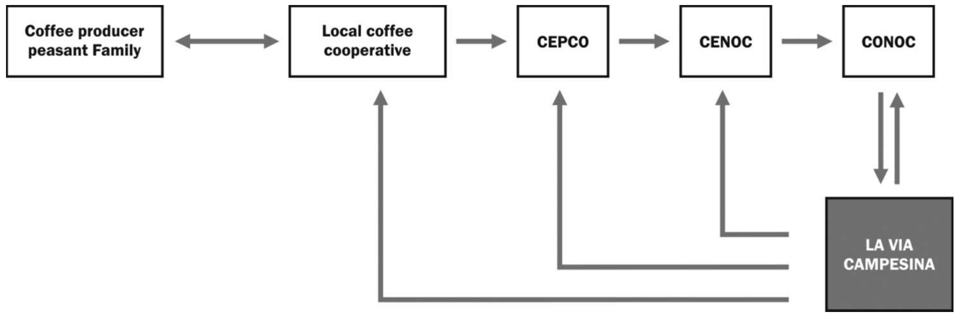

Figure 4. Reciprocity flows of ecological, political, organizational and economic information from local to global levels as exemplified by coffee peasant cooperatives in Oaxaca, Mexico. *Notes*: CEPCO: Coordinadora Estatal de Porductores de Café de Oaxaca; CENOC: Coordinadora Nacional de Productores de Café; CONOC: Coordinadora Nacional de Organizaciones Campesinas.

percent or more are certified organic. Organic coffee was a key strategy used by Mayan farmers first to confront the withdrawal of the government from regulating the coffee sector and the implementation of neoliberal reforms in the 1970s and 1980s and later in the 1990s to deal with the dramatic drop in prices. These circumstances provided farmers greater space to develop their own social capital and organize to pursue alternative 'capital strategies', such as growing organic coffee to gain a price premium from Northern markets (Martinez-Torres 2006). Coffee growers are integrated at the local, regional, national and international level as a mechanism to coordinate linkages to markets, bargain for fair prices and to protect themselves from the challenges involved in entering the industrial and agroexport chains. As illustrated in Figure 4, coffee farmers in Oaxaca belong to a local cooperative which in turn belongs to a state (CEPCO[14]) and a national (CENOC[15]) coffee organization which is linked to a national (CONOC[16]) and a global (*Via Campesina*) peasant organization, creating a reciprocity network from the local to the global with political, organizational and economic information flowing in both directions.

Latin America: a 'boiling' agroecological revolution

Against all writings of academics that predicted the disappearance of the peasantry (for a general background, see discussions in Chayanov *et al*. 1977, de Janvry 1981, Bryceson *et al*. 2000), Latin American *campesinos* have increased their cultural, social and political presence in the region. In fact an evaluation of data from 17 countries revealed that small farmers increased by 220 million between 1990 and 1999 (Toledo and Barrera-Bassols 2008). This phenomena has been termed 'the return of the peasants' (Pérez-Vitoria 2005), or the re-peasantization of the rural spaces, including European territories (Van der Ploeg 2010), which has led to the recognition of the peasantry in their new role in the resistance against the advancement of industrial agriculture and neoliberal policies (Pérez-Vitoria 2010).

[14]Coordinadora Estatal de Porductores de Café de Oaxaca.
[15]Coordinadora Nacional de Productores de Café.
[16]Coordinadora Nacional de Organizaciones Campesinas

One concrete expression of this phenomenon is the emergence of a international peasant organization: *La Via Campesina* (Martinez-Torres and Rosset 2010, Desmarais 2007). Despite some difficulty and occasional tensions, this movement works in synergy with the indigenous movements.

Via Campesina has long argued that farmers need land to produce food for their own communities and for their country and for this reason has advocated for genuine agrarian reforms in the areas of access to and control over land, water, and agrobiodiversity, among others, which are of central importance for communities to be able to meet growing food demands (Martinez-Torres and Rosset 2010). 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 (*Via Campesina* 2010). 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 *et al.* 2006). Rural social movements embrace the concept of food sovereignty as an alternative to the neoliberal approach that puts its faith in inequitable international trade to solve the world's food problem. Instead, food sovereignty focuses on local autonomy, local markets, local production-consumption cycles, and farmer-to-farmer networks that promote agroecological innovations and ideas. Agroecology provides the principles for rural communities to reach food sovereignity but also energy and technological sovereignty within a context of resiliency (see Figure 5). By exploiting the environmental services derived from biodiverse agroecosystems and using locally available resources farmers are able to produce without external inputs; this may be termed *technological sovereignty*. The application of such autochthonous technologies to production systems allows for the production of crops and animals to satisfy household and community demands: *food sovereignty*. *Energy sovereignty* is the right for people inhabiting farms, cooperatives or rural communities to have access to sufficient energy within ecological limits from local and sustainable sources, such as plant biomass produced on farm, without sacrificing food crops. Agroecology provides the principles to design resilient agroecosystems capable of withstanding variations in climate, markets, etc., while ensuring the three broadly distinct but inter-linked sovereignties.

No less important than the permanent three-pronged agroecological revolution in the rural areas is the revolt in the midst of academic and research institutions, where research agendas and curricula orientation have been drastically modified by the agroecological thought. The generation of theoretical and practical agroecological knowledge in the region parallels the initiatives of the social movements. Accompanying these processes are the activities of the *Sociedad Científica Latinoamericana de Agroecología* (SOCLA), composed of about 360 professors and researchers, and the *Movimiento Agroecológico Latinoamericano* (MAELA), grouping hundreds of NGOs advocating for agroeocological change. Both groups play a key role in supporting social movements via the dissemination of know-how, innovations, ideas, debates through congresses, courses, seminars and field projects, and publications such as the widely distributed *Revista LEISA,* published in Spanish and Portuguese.

But despite the positive gains that agroecological movements have had over time in the region, still there are many factors that have limited or constrained the

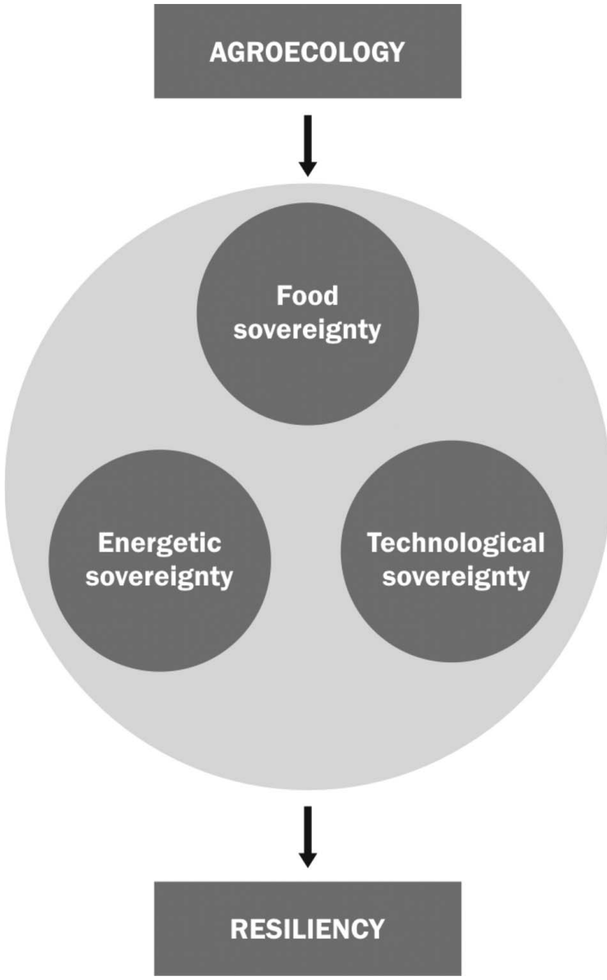

Figure 5. Agoecology, resiliency and the three types of sovereignities to be achieved in a rural community.

diffusion and implementation of agroecological initiatives more fully. Major reforms must be made in policies, institutions, and research and development agendas to make sure that agroecological alternatives are massively adopted, made equitably and broadly accessible, and multiplied so that their full benefit for sustainable food security can be realized. It must be recognized that a major constraint to the spread of agroecology has been that powerful economic and institutional interests have backed research and development for the conventional agroindustrial approach, while research and development for agroecology and sustainable approaches has in most countries been largely ignored or even ostracized.

Whether the potential and spread of local agroecological innovations described above is scaled up to reach all the small farmers of the region depends on the ability of the various actors and organizations involved in the agroecological revolution to make the necessary alliances so that farmers can gain increasing access to agroecological knowledge as well as to land, seeds, government services, solidarity markets, and so on. Rural social movements understand that dismantling the industrial agrifood complex and restoring local food systems must be accompanied by the construction of agroecological alternatives that suit the needs of small-scale producers and the low-income non-farming population and oppose corporate control over production and consumption. Of key importance will be the direct involvement of farmers in the formulation of the research agenda and their active participation in the process of technological innovation and dissemination through *Campesino a Campesino* models where researchers and extension workers can play a major facilitating role.

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