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To cite this article: Clara I. Nicholls & Miguel A. Altieri (2018): Pathways for the amplification of agroecology, *Agroecology and Sustainable Food Systems*, DOI: [10.1080/21683565.2018.1499578](https://doi.org/10.1080/21683565.2018.1499578)

To link to this article: <https://doi.org/10.1080/21683565.2018.1499578>



Published online: 09 Aug 2018.



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Pathways for the amplification of agroecology

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ABSTRACT

A transition to an agriculture based on agroecological principles would provide rural families with significant socio-economic and environmental benefits. If agroecology has such great potential to feeding the world, why it is not adopted more widely by farmers? Most research analyzing factors needed for scaling up agroecology focuses on the social and policy dimensions. Herein we argue that a key challenge for the amplification of agroecology lies in the translation of agroecological principles into practical strategies for soil, water, and biodiversity management to enhance production and resilience. We use old and recent case studies to understand how amplification of agroecology has happened, both in numbers of farmers and at a larger geographical scale. We focus on two main strategies that have proven effective in the past: (a) the revival of traditional agricultural systems which offer promising models of sustainability and resilience and (b) the creation of “agroecological lighthouses” from which principles radiate out to local communities, helping them to build the basis of an agricultural strategy that promotes efficiency, diversity, synergy, and resiliency. Such agroecological strategies must be complemented by policies and solidarity market arrangements to provide economic viability to the amplification of agroecology.

ARTICLE HISTORY

Received 11 March 2018

Revised 3 July 2018

Accepted 9 July 2018

KEYWORDS

Agroecology; traditional agriculture; scaling-up; food systems; social movements

Introduction

Recent reports suggest that a transition to an agriculture based on agroecological principles would not only provide rural families with significant social, economic, and environmental benefits, but would also feed the world, equitably, and sustainably (FAO 2015; IAASTD 2009; IPES-Food 2016). In fact, it has been amply recognized that no less than 50% of the world's food is provided by small-scale food producers on less than 25% of the arable land. Most of the food consumed today in the world is derived from 5,000 domesticated crop species and 1.9 million local plant varieties grown by peasants, farming 20–30% of the arable land without agrochemicals

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or genetically modified seeds (ETC Group 2017). It is important to note that a significant number of small farmers have suffered a process of de-peasantization by adopting monocultures and external inputs (Van Der Ploeg 2009). If a massive number of these farmers would undertake agroecological conversion schemes in their farming systems, their contribution to global food security would be even more significant.

A common criticism of agroecology is that if it has such great potential to address the multiple challenges facing agriculture, why it is not adopted more widely by farmers? For sure, very few resources have been devoted for agroecology research and extension and almost no policy support has been directed to agroecology. Despite this neglect, millions of smallholders have adopted and spread agroecology farmer to farmer. These initiatives have been implemented with less than 10% of the funding devoted to the 15 international research centers of the CGIAR, an unprecedented return on agricultural technology investment. Particularly in Latin America, agroecology has had a tangible, positive impact on crop yields, resource conservation and food security (Altieri and Toledo 2011). By growing a diversity of different locally adapted crops, many small and family farmers provide for a range of nutritional needs at the household and community level, and reduce risks from variability in weather and dependence of external expensive inputs. Moreover, agroecology reduces farmers' costs and debts and enhances their autonomy and control over their territories and means of production (Rosset and Altieri 2017).

Many people have suggested various ways to overcome the barriers to scaling up and scaling out agroecology (Parmentier 2014; Varghese and Hansen-Kuhn 2013). A long list of suggestions ranging from creating an enabling environment, providing the right incentives to farmers, creating special markets, fund more research and education on agroecology can be found on the literature (Giraldo and Rosset 2017). It is true that there is an urgent need for reforms in policies, institutions, and research and development agendas to ensure that agroecological alternatives are adopted widely, made equitably and broadly accessible. But real barriers are more structural in nature. Undoubtedly, a key obstacle for scaling up agroecology is the need to address the structural 'lock-in' preventing a transition to agroecology that lies in the political-economic control of food systems, seeds, technologies, information outlets and even research agendas in public national and international research systems by what has been termed the corporate food regime (Holt-Gimenez 2017; IPES 2016).

Another major challenge facing the agroecological movement is that the gap between the socio-political discourse on the agroecological transition and the actual practice of agroecology is widening. In other words, the sophisticated political analysis on food sovereignty is not always matched and backed by concrete agroecological initiatives on the ground, which are needed to solve real and urgent technical problems in rural communities. Closing the gap will require

placing on equal footing social and agricultural transformations. In their analysis of key drivers for scaling up agroecology, Mier Y Terán Giménez Cacho et al. (2018) recognize that the existence of effective agroecological practices is an important one. This implies collective action to translate agroecological principles into practical strategies for soil, water, and biodiversity management to enhance production and resilience, as it was done by pioneering NGOs connected to peasant organizations in the 1980s in Latin America (Altieri 1999). Understanding the ways successful farmers use biodiversity and the ecological underpinnings of their complex farming systems, and then spreading such principles farmer to farmer has shown to be an effective avenue to speed the development of productive, sustainable and resilient agroecosystems. Another pathway is for agroecologists and farmers to blend traditional and western knowledge to create novel farm designs, well adapted to local circumstances so that they can serve as demonstration modules or “agroecological lighthouses” from which agroecological principles and lessons radiate out to the broader rural communities. Such approaches have proven valuable for concrete agroecological initiatives to be disseminated and expanded, both in numbers of farmers and at a larger geographical scale. All these strategies must of course be complemented by enabling policies and solidarity market arrangements between farmers and consumers in order to provide economic viability to the scaling up of agroecology.

In this paper, we intend to contribute to unleashing agroecology’s scaling-up processes by identifying and analyzing initiatives that allowed agroecology to “amplify” beyond isolated local experiences to include more farming families in larger territories. Many of the initiatives described herein have led to the amplification of knowledge about agroecology principles among farmers and allies, integrating practice and science at the farm and landscape level. The idea is not to impose technical fixes, but increasing the power of agroecology by mobilizing collective creativity and social ingenuity, while diversifying food provisioning, consumption, and marketing strategies (Giraldo and Rosset 2017). The analysis of these initiatives can shed light on new pathways for amplifying agroecological transformations at the territorial level.

Reviving traditional farming systems

As the inability of the Green Revolution to improve production and farm incomes for the very poor became apparent, a new enthusiasm for ancient technologies spearheaded a quest in the developing world for affordable, productive and ecologically sound technologies that enhance small farm productivity while conserving resources (Altieri 2002). Many traditional agricultural systems offer promising models for other areas as they promote biodiversity, thrive without agrochemicals, and sustain year-round yields even in the midst of ecological marginality and climate change (Koohafkan and Altieri 2017).

One of the early projects advocating this approach occurred in the late-1980s in the Andes, where several institutions engaged in programs to restore abandoned terraces and build new ones in various regions of the country. In the Colca Valley of southern Peru, PRAVTIR (Programa de Acondicionamiento Territorial y Vivienda Rural) sponsored terrace re-construction 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, extends 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 labor-intensive, requiring about 350–500 workers/day/ha. Such demands, however, can be buffered when communities organize and share tasks (Treacey 1989).

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. 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 soils. In the Huatta district, reconstructed raised fields produced impressive harvests, exhibiting a sustained potato yield of 8–14 tons/ha/yr. These figures contrast favorably with the average Puno potato yields of 1–4 tons/ha/yr (Erickson and Chandler 1989).

In more arid and semiarid regions, farmers have over generations developed management options that can increase the soil's ability to store water for plant use, reduce vulnerability to drought, as well as help halting soil erosion and degradation. In many parts of Burkina Faso and Mali there has been a revival of the old water harvesting system known as "zai". The zai are pits that farmers dig in often rock-hard barren land, into which water otherwise could not penetrate. A "zai" is typically between 10 and 15 cm deep and 20–30 cm in diameter and are filled with organic matter (Critchley 1989). The application of manure in the pits further enhances growing conditions, and simultaneously attracts soil-improving termites, which dig channels and thus improve soil structure so that more water can infiltrate and be held in the soil. By digesting the organic matter, the termites make nutrients more easily available to plants. In most cases farmers grow millet or sorghum or both in the zai. At times they sow trees directly together with the cereals in the same zai. At harvest, farmers cut the stalks off at a height of about 50–75 cm, which protect the young trees from grazing animals. Farmers use anywhere from 9,000 to 18,000 pits per hectare, with compost

applications ranging from 5.6 to 11 tons/ha (Critchley, Reij, and Willcocks 2004).

Over the years, thousands of farmers in the Yatenga region of Burkina Faso have used this locally improved technique to reclaim hundreds of hectares of degraded lands. Farmers have become increasingly interested in the zai as they observe that the pits efficiently collect and concentrate runoff water and function with small quantities of manure and compost. The use of zai allows farmers to expand their resource base and to increase household security. Yields obtained on fields managed with zai are consistently higher (ranging from 870 to 1590 kg/ha) than those obtained on fields without zai which average 500–800 kg/ha (Reij, Scoones, and Toulmin 1996).

Campesino a campesino methodology

The *Movimiento Campesino a Campesino* (CAC-Farmer to Farmer movement) is a grassroots movement in sustainable agriculture that emerged in Mexico and has swept across Central America and now other countries. For more than 30 years, CAC has involved several hundred thousand farmer-promoters in helping farming families in the rural villages of Latin America improve their livelihoods and conserve their natural resources. CAC is a cultural phenomenon creating pedagogical mechanisms that link campesino communities across village, municipal, and national divisions using agroecology and horizontal learning networks. It uses participatory methods based on local peasant needs and allows for the socialization of the rich pool of family and community agricultural knowledge that is linked to their specific historical conditions and identities. By exchanging innovations among themselves, peasants have been able to make dramatic strides in food production relative to the conventional sector, while preserving agrobiodiversity and using much lower amounts of agrochemicals (Holt-Giménez 2006; Rosset and Martínez-Torres 2012).

Central America

The use of “green manures” has made it possible to intensify the old technique of slash-and-burn to produce maize and other crops in areas where long fallow periods are not possible anymore. The system diminishes drought stress, because the mulch layer left by cover crops helps conserve water in the soil profile, making nutrients readily available in synchrony with periods of major crop uptake. In addition, the legume velvet bean (*Mucuna* sp.) suppresses most weeds, either by physically preventing them from germinating and emerging, or by inducing shallower rooting in the litter layer–soil interface, making them easier to control. Data show that this system, involving the continuous annual rotation of velvet bean and maize,

can be sustained for up to at least 15 years with reasonable yields, and without signs of soil degradation (Buckles, Triomphe, and Sain 1998).

Within one year, a crop of velvet beans can fix up to 150 kg of nitrogen per hectare, benefitting maize crops as the fixed nitrogen is released into the soil. In addition, the *Mucuna* also produces up to 35 tons of organic matter per hectare. By cutting *Mucuna* and allowing the leaf material to compost naturally in the fields, soils are being recreated. Now, across Guatemala and Honduras, some 47,000 farm-families are benefiting from the adoption of cover crops. In just one year, more than 1,000 peasants recovered degraded land in the Nicaraguan San Juan watershed. Alongside the use of simple technologies, such as sowing grass strips along contours, building rock bunds and in-row tillage, the velvet bean has helped regenerate local economies. Adoption of velvet bean tripled maize yields to 2500 kg/ha and reduced soil erosion, while labor requirements for weeding were cut by 75%. Due to the many benefits of cover crops, it is estimated that in Central America and Mexico, an estimated 200,000 farmers are experimenting with some 14 different species of green manure and cover crops (Bunch 2012).

Cuba

Agroecology played a key role during Cuba's food crisis caused by the collapse of the socialist bloc in 1989–90 and the subsequent tightening of the US trade embargo. Cuban peasants were able to boost food production without scarce and expensive imported agricultural chemicals by making a transition to more-diverse, agroecologically integrated farming systems. Peasant agriculture's rapid transition was possible thanks to the adoption of the CAC methodology promoted by the National Association of Small Farmers (ANAP), which by 2010 had reached one-third of all peasant families in Cuba. This movement has now grown to include some two hundred thousand peasant families, about one-half of the Cuban peasantry who have been able to diversify and enhance their production without dependence on external inputs. As a consequence, Cuban peasants' contribution to national food production has increased significantly. It is estimated that agroecological practices are used in 46–72% of the peasant farms producing over 70% of the domestic food production, for example 67% of roots and tubers, 94% of small livestock, 73% of rice, 80% of fruits and most of the honey, beans, cocoa, maize, tobacco, milk, and meat production (Rosset et al. 2011).

Observations during the last decade have revealed that many of these peasant farms exhibit high levels of resiliency to climate disasters. 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% compared to 90–100% in neighboring farms

growing monocultures. Likewise, agroecologically managed farms showed a faster productive recovery (80–90% 40 days after the hurricane) than monoculture farms. These evaluations emphasize the importance of enhancing plant diversity and complexity in farming systems to reduce vulnerability to extreme climatic events; a strategy entrenched among Cuban peasants (Altieri et al. 2013).

Cuba's achievements in urban agriculture are equally remarkable—there are 383,000 urban farms, covering 50,000 ha of otherwise unused land and producing more than 1.5 million tons of vegetables with top urban farms reaching a yield of 20 kg/m² per year of edible plant material using no synthetic chemicals—equivalent to a 100 tons/ha. Urban farms supply 70% or more of all the fresh vegetables consumed in cities, such as Havana and Villa Clara (Clouse 2014). The expansion of urban agriculture in the island was a response to the difficulty of transporting food from rural areas. Social organization and collective action were key to launching urban farming, but government support in the form of extension services, supply of basic inputs, and making land accessible eventually also proved critical.

Farmers' lighthouses

Demonstration farms

During the 1990s, several NGOs promoted the integrated use of a variety of agroecological management technologies and practices. The emphasis was on the design of diversified farms that served as “agroecological lighthouses” from which agroecological principles radiate out to the community and farmers from other regions, helping them to build the basis of an agricultural strategy that promotes efficiency, diversity, synergy, and resiliency (Altieri 1999). With the advent of the internet and other information outlets, many successful farmer-run operations have been given visibility as lighthouses providing living testimonies on how to design and manage farms based on agroecological principles.

NGO led lighthouses

CET, Chile

Since 1980, the Centro de Educacion y Tecnologia (CET), a Chilean NGO has been engaged in rural development programs aimed at helping peasants reach year-round food self-sufficiency while rebuilding the productive capacity of their small land holdings. The approach consisted in setting up several 0.5 ha model farms, with spatial and temporal rotational sequence of forage and row crops, vegetables, fruit trees, and animals. Components are chosen according to crop or animal nutritional contributions to subsequent

rotational steps, their adaptation to local agroclimatic conditions, local peasant consumption patterns and finally, market opportunities.

Model farms are typically managed by a family of five who grow most vegetables in heavily composted 12–15 m² raised beds located in the garden section, each of which can yield up to 83 kg of fresh vegetables per month. An evaluation conducted during the 1994–1995 growing season of an 11.05 m² bed of the intensive garden, revealed that total productivity of 16 crop species reached 177.4 kg per year or 16 kg/m² per year (Infante 1986). The rest of the 200 m² area surrounding the house is used as a multi-fruit species orchard, and for animals (chicken, rabbits, langstroth beehives and 1–2 cows). The majority of grain, tuber, and forage crops were produced in an adjacent half-hectare plot featuring a six-year rotational system adjacent to the garden. Relatively constant production is achieved (about 6 tons per year of useful biomass from 13 different crop species) by dividing the land into as many small fields of equal productive capacity as there are years in the rotation (Altieri 2009). The rotation that circulates in a counter-clockwise direction is designed to produce the maximum variety of crops in six plots, taking advantage of the soil-restoring properties and biological control features of the rotation (Figure 1). The half-hectare field is surrounded by 70 fruit trees belonging to 13 species. A nutritional analysis of the system based on its key components shows that the agroecologically designed farm, after satisfying 95% of the nutritional needs of a typical family of five (a savings of about US\$400/month), produces a food surplus that if sold provides a net income of US \$790 (Table 1). More than 20,000 farmers, students, and government and NGO technicians visited this lighthouse in a period of 7 years.

CET's lighthouse in the Bio-Bio region of Chile is visited by 7,000 persons per year (85% campesinos, 12% technicians and 2% students) totaling no less than 130,000 visitors during a period of 20 years. Considering that the population of small farmers in Chile is about 280,000 people, it is estimated that no less than 1/3 of the Chilean small farmers have been exposed to the agroecological proposal exhibited in CET's Bio-Bio demonstration farm. Interestingly, the majority of farmer visitors have been women (> 65%) over 45 years of age (Infante 2015).

Instituto de Investigación de Pastos y Forrajes

At the Cuban Instituto de Investigacion de Pastos y Forrajes, several agroecological modules with various proportions of the farm devoted to agriculture and animal production were established. Monitoring of production and efficiencies of a 75% pasture/25% crop module reveals that total production increased over time, and that energy and labor inputs decreased as the biological structuring of the system begins to sponsor the productivity of the agroecosystem. Total biomass production increased from 4.4 to 5.1 tons/ha after 3 years of integrated management. Energy inputs decreased, which

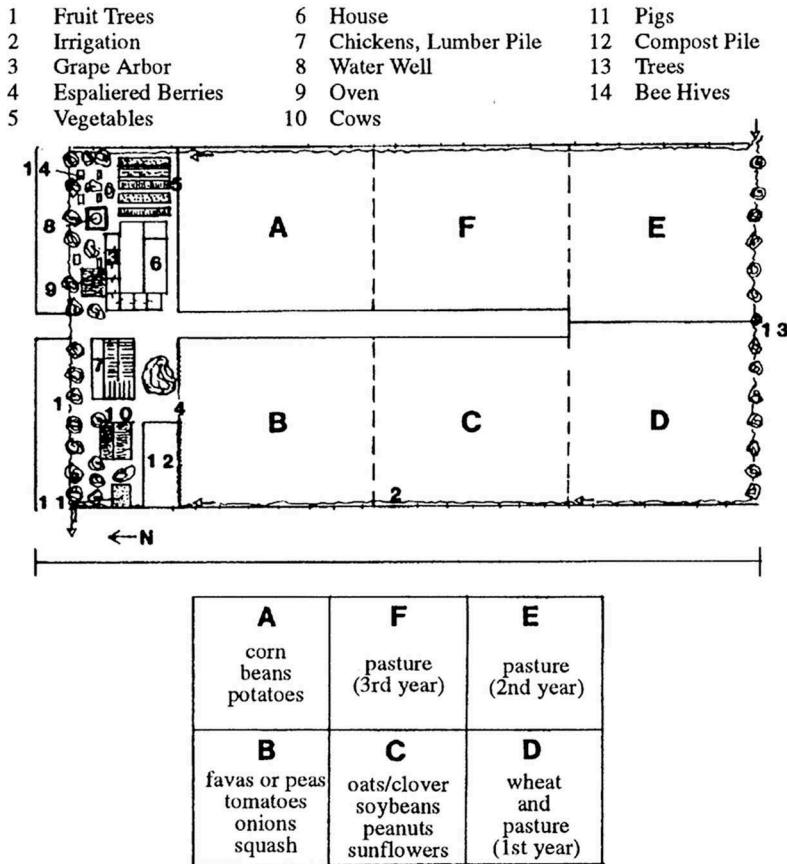


Figure 1. Six- year rotational farm design that served, during two decades, as a demonstration agroecological lighthouse in Central Chile to thousands of farmers and technicians (Altieri 2009). Plots A to F circulate yearly in a counter clockwise direction (plot F moves to where A was, Plot A moves to where B was and so on).

resulted in enhanced energy efficiency from 4.4 to 9.5 (Table 2). Human labor demands for management also decreased over time from 13 h of human labor/day to 4–5 h. Such models have been promoted extensively in other areas through field days and farmers’ cross visits. Farmers trained in the Cuban lighthouse and who applied agroecological methods in their own farms obtained yields per hectare sufficient to feed about 15–20 people per year with energy efficiencies of no less than 10:1 (Funes-Monzote 2008).

In 1995, the Asociacion Cubana de Agricultura Organica (ACAO) helped establish three integrated farming systems called ‘agroecological lighthouses’ in cooperatives (CPAs) in the province of Havana. After the first six months, all three CPAs had incorporated agroecological innovations (i.e. tree integration, planned crop rotation, polycultures, green manures, etc.) to varying degrees, which over time, led to enhancement of production and biodiversity, and improvement in soil quality, especially organic matter content. Several

Table 1. Productivity of a half hectare Chilean peasant farm after three years of agroecological re-design (Altieri 2009).

PRODUCTION	Commercial Value..... 2.435 USD
Rotation..... 3,16 t*	Production costs..... 780 USD
Home garden.....1,12 t**	Income..... 1.600 USD
Fruits.....0,83 t***	Surplus nutritional output:*
Milk.....3.200 l	Protein.....310%
Meat 730 kg	Calories..... 120%
Eggs.....2.531 u	Vit. A 150%
Honey 57 kg	Vit. C.....630%
	Ca 400%
	P 140%
	% of nutrients after meeting family food needs

*The rotational design was composed of six plots: (a) three planted with alfalfa to provide forage for cow and horse, and to charge the system with biomass and nitrogen, (b) three planted with various summer and winter food crop combinations that are more nutrient extractive. Plots circulated on a yearly basis in an anti-clockwise direction, thus the rotation ensured restoration of biomass and nutrients, breaking life cycles of insect pests, pathogens and weeds, and diversifying temporal production.

** Fruits were derived from trees of various species planted in borders of the rotational field.

*** Most vegetables were derived from the intensive garden around the house.

Table 2. Productive and efficiency performance of the 75% animal, 25% crop integrated module in Cuba (Funes and Vazquez 2016).

Productive parameters	1st year	3rd year
Area (ha)	1	1
Total production (t/ha)	4.4	5.1
Energy Produced (Mcal/ha)	3797	4885
Protein produced (kg/ha)	168	171
Number of people fed by one ha	4	4.8
Inputs (energy expenditures, Mcal)		
• Human labor	569	359
• Animal labor	16.8	18.8
• Tractor energy	277.3	138.6

polycultures, such as cassava-beans-maize, cassava-tomato-maize, and sweet potato-maize were tested in the CPAs. Productivity evaluation of these polycultures indicates 2.82, 2.17 and 1.45 times greater productivity than monocultures, respectively. The use of green manures ensured a production of squash equivalent to that obtainable applying 175 kg/ha of urea. In addition, such legumes improved the physical and chemical characteristics of the soil and effectively broke the life cycles of insect pests, such as the sweet potato weevil (Funes and Vazquez 2016).

Centro IDEAS, Peru

In the Inter-Andean valleys of Cajamarca, in Peru, Centro IDEAS implemented a 2 ha agroecological module inserted in an area with similar biophysical conditions facing the average campesino of the region (Alvarado De La Fuente 2008).

The farm was divided into nine plots, each following a rotational design featuring:

- Intensive use of human and animal labor.
- High diversity of Andean and exotic crops, herbs, shrubs, trees, and animals grown in polycultural and rotational patterns.
- Conservation of soil and water and creation of favorable microclimates using shelterbelts, living fences, and reforestation with native and exotic fruits and trees.
- Recycling of organic residues and optimal management of small animals.

After 3 years of operation, field results showed that organic matter content, nitrogen, phosphorus and potassium increased in all plots. Crop yields varied among plots, however in plots with good soils, high yields of corn and wheat were obtained. Polycultures featuring various combinations of maize, beans, quinoa, amaranth and squash, over-yielded monocultures in all instances.

To farm 1 ha of the model farm it was necessary to use 100 person-hours, 15 oxen-hours, and about 100 kg of seeds. These preliminary results indicate that the proposed farm design enhances the diversity of food crops available to the family, increases income through higher productivity, and maintains the ecological integrity of the natural resource base. Since then, this model experience was extended to hundreds of farmers who have undergone conversion to agroecological management in the Peruvian Sierra and Coast. A recent evaluation of the experiences showed that after a 2–5-year conversion process, income improved progressively due to a 20% increase in productivity. Of the 33 different agroecological practices offered by IDEAS, more than 80% of the farmers favored organic fertilization, intercropping, animal integration, and agroforestry systems (Alvarado and Ramirez 1998).

As in the case of the Chilean (CET) lighthouse, the IDEAS demonstration farm was located in the field in the midst of a rural area, thus providing demonstration and training from local practice. The amplification approach emphasizes field days, farmer exchanges, and other training activities at the lighthouse where technical knowledge and agroecological processes are shared to guide local producers towards the design of more sustainable agroecosystems. The technical, social, and cultural proposals established at the lighthouse were constantly nourished by closely working with the peasants that visited from local and distant communities. Over a period of five years, more than 20,000 farmers and technicians visited the IDEAS demonstration farm.

El Hatice nature reserve, Colombia

Silvopastoral systems (SPS), combine fodder plants, such as grasses and leguminous herbs, with shrubs and trees for animal nutrition and

complementary uses. Such agro-landscapes favor biodiversity by creating complex habitats that support diverse plants and animals, harbor a richer soil biota, and increase connectivity between forest fragments. Trees and palms provide farmers with marketable wood products but also fruits, seeds, and pods that feed humans, cattle, and wild animals. At the same time, trees in SPS also provide a range of indirect benefits, such as maintenance and improvement of soil fertility, nitrogen fixation and nutrient uptake from deep soil horizons, while their litter helps replenish soil nutrients, enhance organic matter, and support complex soil food webs, including dung beetles and other decomposers that quickly recycle nutrients (Calle et al. 2013).

El Hatigo nature reserve is one of the farms that pioneered the use of SPS, located in the fertile flatlands of the Cauca river in Colombia. Until 1970 *El Hatigo* used monoculture grasslands with herbicides for weed control, irrigation during dry periods, chemical fertilization, and animal loads below three cows per hectare. After a 5-year agroecological conversion to SPS *El Hatigo* today features complex SPS composed of five plant strata. The SPS and rotational grazing systems used over the past 18 years have allowed the increase of stocking rates to 4.3 cows per hectare and milk production by 130% and to completely eliminate the use of fertilizers. In 2009 in the midst of the driest year in *El Hatigo's* 40-year record, with precipitation having dropped by 44% compared to the historical average, pasture biomass was reduced in 25%, but fodder production of trees and shrubs remained constant throughout the year, neutralizing the negative effects of drought on the whole system (Murgueitio et al. 2011).

El Hatigo has become a major research and education demonstration center featuring the development of environmentally friendly agriculture and livestock production systems. Hundreds of farmers, students, scientists, and other people have benefited from *El Hatigo* short courses, field days, and other outreach activities which have spread the principles of SPS allowing farmers to integrate diverse tree species into their production systems. Farmers (large and small) that have adopted SPS have observed a rapid increase in productivity and the rehabilitation of degraded pasturelands. In Colombia, participatory research on actual farms contributed to optimizing SPS in different agroecosystems and strengthened a network of pilot farms (of which *El Hatigo* is a part) open to research and peer-to-peer technology transfer (for more information see Proyecto de Ganaderia Colombiana Sostenible-www.cipav.org.co).

Finca del medio, Cuba

Finca del Medio is a 10 ha farm located in Sancti Spiritu, representative of a typical family farm in Cuba, managed by the Casimiro-Rodriguez family. Since 1995, the farm has undergone a radical agroecological conversion, for

which a multi-plow implement pulled by animal traction invented by these farmers, was critical to overcoming the labor limitations during the transition. The multi-plow is useful to remediate soil compaction, efficiently incorporate crop residues into the soil to enhance organic matter, control weeds and to allow planting many crops given the adjustability of the implement to vary row widths, planting depth, etc. The farm features an array of polycultures, agroforestry systems, rotations and animal integration schemes surrounded by a network of multipurpose hedgerows. Biodigestors and windmills provide energy for cooking and other uses, and the farm has a complex set of water harvesting mechanisms to enable production during the dry season. Total output of the farm is about 7 tons/ha/yr, which can provide the calories and protein needs of 30 persons per year (Casimiro, Casimiro, and Hernandez 2017). Such levels of productivity are achieved with almost no inputs (only 2% of external inputs), and human labor needs limited to 730 h/ha/yr (neighboring conventional farms need about 2330 h/ha/yr). It is estimated that if in Cuba, 100,000 family farms adopted the agroecological model of *Finca del Medio*, enough production could be obtained to feed 6,000,000 people. Such a goal could be easily reached as more than 2,000 farmers visit this farm every year, as well as hundreds of international visitors, who benefit from the lessons gleaned from this lighthouse.

Reconfiguring agroecological territories

There are many examples of entire rural communities engaged in agroecological transition processes at the territorial level, involving the widespread use of agroecological practices, biodiversity and resource conservation schemes and territory-linked embedded food systems.

Chiloe: a globally important agricultural heritage system (GIAHS) initiative

The Archipelago of Chiloé, in the south of Chile, is a rich land in mythology, with native forms of agriculture practiced for hundreds of years based on the cultivation of numerous local varieties of potatoes, garlic, apples, sheep, etc., all embedded in a rich landscape of virgin forests, home of many species of endemic flora and fauna in danger of extinction. Traditionally, the indigenous communities and farmers of Chiloé cultivated about 800–1,000 native varieties of potatoes before the onset of agricultural modernization. The 200 native potato varieties that still exist at present are the result of a long domestication process, selection, and conservation made by ancient Chilotes. For today's farmers, these varieties have a special importance and they always reserve a space in their farms to plant them. Rural women have traditionally carried out the biodiversity conservation activities in the small plots of their family vegetable gardens. Women are thus a key source of

knowledge about on-farm seed conservation, cultivation, and potato-based gastronomy in their respective communities (Venegas 2009).

Most traditional farmers manage potatoes with agroecological practices (use of no till systems, intercropping with fava beans or peas which fix nitrogen) and using local resources, such as the use of marine algae for fertilization and manure from animal corrals as fertilizer sources. Chilotan farmers rotate their potato crops with wheat and forage legumes to avoid pest and disease build up. Several old apple varieties are grown in small orchards with a cover of native vegetation grazed by local races of sheep. In addition, many farmers preserve native forest fragments from where they derive wood and a number of non-timber products. Others harvest from the wild or grow a variety of medicinal plants. Most of these products are for subsistence use, but a small surplus is sold in local markets in nearby towns or cities (Venegas 2011).

Various actors and social networks in Chiloé are actively engaged in exploring endogenous development strategies based on the revalorization of the cultural heritage and its elements embedded in the rural territories. The Centro de Educacion y Tecnologia (CET) played a major role in obtaining the designation of Chiloe as a humankind agricultural patrimony by FAO under the GIAHS initiative (www.fao.org/giahs/en/). This designation initiated a process of appreciation of the intrinsic values of Chilotan agricultural patrimony, exploring opportunities on how to balance conservation, socio-economic development, and adaptation through the promotion of ancient knowledge systems and by capitalizing on heritage' goods and services. The Chiloé's GIAHS dynamic conservation opened up many opportunities for collaborative partnerships between and among local stakeholders to valorize and benefit from the intrinsic values of ancestral knowledge systems and practices. One of the most important milestones achieved between 2013 and 2014 in Chiloé was the introduction of a certification seal, the "*Sistemas Ingeniosos del Patrimonio Agrícola Mundial (SIPAM)—Chiloé*". The SIPAM seal has been a powerful tool for recognizing and visibilizing the importance of indigenous family farming in Chiloé (Venegas and Lagarrigue 2014).

The SIPAM seal has been instrumental for the promotion of the island's culturally distinct products, and creating market processes tailored to consumers (locals and tourists) who prefer products differentiated by origin and cultural quality. In the case of Chiloé, located in a biodiverse area of global importance, linking cultural capital with natural resources is starting to provide the foundation of a territorial development strategy with cultural identity, directly involving the native people and their knowledge systems. Many municipalities are mobilizing to protect the cultural patrimony of their areas. A few market agents are starting to play a role by investing in specialized tourist agencies and

supermarkets and restaurants that offer local products with the *SIPAM* 's seal (Venegas and Lagarrigue 2014).

El Dovio, Colombia

In much of the western Cordillera of Colombia, forests have disappeared as a result of the expansion of the agricultural frontier. This loss of forests accelerates the deterioration of soils, the local extinction of species and the degradation of ecosystems. In the Bellavista village of *El Dovio*, the peasant community has been involved for two decades in a participatory research process along with the nongovernmental organization CIPAV (www.cipav.org.co). Much of the technology developed for sustainable agricultural production, water decontamination and the ecological restoration of Andean forests was the result of a dialogue of knowledge among technicians, scientists and peasants of this community. Of particular importance was the participation of the group "Heirs of the Planet" of Bellavista composed of 30 children, youth and adults aged between 4 and 26 years. This group represents the generational change that guarantees the continuity of the processes of sustainable development, community participation, and consequently the strengthening of cultural identity (Calle, Giraldo, and Piedrahita 2011). All these community efforts led to the restoration of a micro watershed, which in turn restored the water courses and the forest cover, allowing the flourishing of agriculture for the food security of about 75 families with many additional benefits (Table 3).

CIPAV has also promoted agroforestry systems in the region, where farmers intercrop beans, cassava and maize under coffee trees that enhance land use efficiency, reduce use of fertilizers and produce food crops, which are key for subsistence, especially if coffee fails or prices are low. Farmers have also adopted SPS experiencing similar benefits to those observed in El Hatice (Section 4.2.1. above).

CEDICAM, La Mixteca

The Mixteca region is inhabited by about 450 thousand people, mostly indigenous peoples, from at least seven different ethnic groups. It is one of Mexico's poorest agricultural regions, exhibits high levels of marginalization, and, therefore, a considerable number of its inhabitants are forced to migrate. As a result of historical processes of deforestation, overgrazing and agricultural expansion that followed the Spanish conquest, soil erosion has reached disastrous levels. It is estimated that 83% of the Mixteca soils are lightly to moderately degraded and 17% exhibit severe erosion signs. The ecological degradation process is shrinking the amount of land available for agriculture. Rain fed areas devoted to grain crops have declined sharply, reaching today

Table 3. Impacts of the restoration effort in Comunidad Bellavista-Colombia (Calle, Giraldo, and Piedrahita 2011).

Aspects	1993	2016
Conservation	<ul style="list-style-type: none">✓ Fragmented forests✓ Biodiversity loss	<ul style="list-style-type: none">✓ Fragments of forest connected and enriched with useful tree species✓ Creation of a natural reserve controlled and managed by the community
Water for consumption	<ul style="list-style-type: none">✓ Water available for farming, animals and household use only for 25 families	<ul style="list-style-type: none">✓ Water available for farming needs and household use by 75 families
Water quality	<ul style="list-style-type: none">✓ High sedimentation and poor water quality	<ul style="list-style-type: none">✓ Low sedimentation, decontamination and improved water quality
Agricultural production	<ul style="list-style-type: none">✓ Monoculture✓ Dependence on external inputs✓ Negative environmental impacts✓ Loss of food sovereignty	<ul style="list-style-type: none">✓ Diversification of production systems✓ Agroforestry systems✓ Rational use of soil, water and biodiversity✓ Land use planning✓ Food Sovereignty (families produce 90% of what they consume)✓ 70% reduction in use of external inputs

less than 25,000 ha. Ninety-one percent of these lands (*agricultura de temporal*) are managed by small farmers that cultivate 1–2 ha plots per year conforming a massive mosaic of more than 120,000 impoverished and degraded minifundios. In addition to land degradation, the Mixteca's most serious problem is water. Many families survive with only 7 L a day. Little or no water is left for animals or to irrigate crops (Rogé et al. 2014).

The Centro de Desarrollo Integral Campesino de la Mixteca Alta (CEDICAM) composed of a number of indigenous farmer promoters and facilitators started in 1997 a process of ecological restoration of these degraded lands. In a period of 5 years, CEDICAM projects planted more than 1 million native trees in the area of Tilantongo. In addition to reforestation and ditch building, efforts center on improving soil fertility, rain water harvesting at the field level, conservation of local genetic resources, design of polycultures and crop rotations, all key strategies for enhancing agricultural productivity. Restoration efforts were strategically planned so that they directly affected farming system performance via enhanced soil fertility and moisture levels. This requires a coordinated plan of watershed restoration and also recuperating local varieties, as well as re-constructing pre-hispanic barriers (called *bordos*) and terraces. The strategy emphasizes soil and water conservation in a way that potentiates farming system enhancement, encouraging a participatory process that leads to technical capacity building and empowerment of farmers. More than 1,000 farmers have been trained and no less than 500 ha have been restored. A series of erosion control canals have been constructed and maintained by trained farmers, significantly contributing to soil conservation. No doubt without their efforts the levels of soil erosion and environmental quality of the region would have reached unsustainable proportions (Dahl-Bredine et al. 2015).

Alternative food networks

Today agroecology has been taken up by rural social movements and is seen as a transformative science, practice, and movement that is explicitly committed to a more just and sustainable future by reshaping power relations from farm to table (Rivera-Ferre 2018). Under the banner of food sovereignty, an ever-increasing diversity of actors (farmers' organizations, progressive academics, NGO people, consumers, and environmentalists) is forming transnational agrarian and food justice movements that oppose the corporate-dominated global agri-food system. They call for a fundamentally different vision of food and how we produce and consume food, while contributing to the creation of local economic and resource circulation and inclusive, equitable food systems (Holt-Gimenez 2017).

Many initiatives and actors driving alternative food system practices exist. Some of the most promising initiatives include short food supply chains,

direct marketing schemes, cooperative marketing, farmers' markets, sustainable local public procurement, community and school gardens, exchange systems, and on-farm direct consumption. In Latin America, several solidarity economic movements were born driven by community-based enterprises designed to meet local needs, and include producer and consumer cooperatives, local credit associations, collective kitchens organizations to support marginalized populations, etc. (FAO 2016). An emblematic example is the ECOVIDA network in southern Brazil, an initiative that builds local commercial networks integrating NGOs, consumer cooperatives, and peasant farmer organizations that practice agroecology. *Ecovida* has a decentralized structure encompassing 180 municipalities and approximately 2,400 families of farmers (around 12,000 persons) organized in 270 groups, associations, and cooperatives. They also include 30 NGOs and 10 ecological consumers' cooperatives. All kinds of agricultural products are cultivated and sold by the *Ecovida* members, including vegetables, cereals, fruits, juice, fruit-jelly, honey, milk, eggs and meat reaching thousands of consumers (Perez 2012).

The ECOVIDA process opened spaces of autonomy for family farmers, increasing their capacity to intervene in markets, stimulating the diversification of production, improving levels of food self-sufficiency, strengthening processes of social organization while reconstructing solidarity relations with consumers to whom they sell their surplus at fair prices. Alternative marketing schemes, such as ECOVIDA have the potential of promoting food and nutritional sovereignty in its various dimensions.

Favorable policies

Despite the overall importance given to the development of public policies in support of agroecology, the limited experience in this realm suggests that no one single policy is key, rather it seems that combinations of complementary policies are needed to incentivize the spread of agroecological initiatives (Giraldo 2018). In some cases, however, public policies can create dependencies that weaken farmers' adoption of agroecology. For example, although credit access could enhance the use of agroecological practices, often it is positively associated with an increase in agrochemical use.

Perhaps the most effective policy promoting agroecology has been public food procurement programs, such as Brazil's National School Feeding Program (PNAE). The program stipulates that 30% of the food procured for schools must be produced by small-scale farmers. In 2012, the program included 185,000 family farms who each sold an average of R\$4554 (Brazilian reais—about US\$2058) worth of crops to 17,988 registered public and non-governmental agencies. Family farms, whose main buyer was public or cooperative, had an average income of R\$1361 in 2011, while those who sold to intermediaries earned R\$493. By 2012, about 2,000 municipalities

participated and about 45 million students/day were served (Wittman and Blesh 2017).

The PNAE includes incentives for agroecology certification that can help farmers overcome constraints to adopting agroecological practices. Researchers found that the PNAE offers an economic incentive to begin an agroecological transition by creating a price-differentiated market, which is usually not present in the small farming regions. Researchers found that without broader participation in agricultural networks, including farmers' associations, cooperatives and extension agencies that support agroecological practices, the PNAE's influence was limited in stimulating the broader transition to agroecological production practices in South Brazil (Petersen, Mussoi and del Soglio 2012). In fact, researchers currently evaluating the impacts of policies, such as the PNAE on the adoption of agroecological practices, question whether such policies create enough incentives and a mobilizing power for more farmers to adopt agroecological practices (Borsatto unpublished data).

Nevertheless, the few experiences around the world derived from public or institutional procurement suggest that when there is political will, this is an effective strategy to promote the progressive realization of the right to adequate food through opening up new marketing channels for smallholder produce. They also offer a range of other benefits, such as the reduction in food miles and access to fresh and nutritious food for local consumers (FAO 2016).

Conclusions

It has been well established that small farmers can produce much of the needed food for rural and urban communities, in the midst of climate change and without dependence on expensive agrochemical inputs. Such contributions could be amplified if agroecology was extended to optimize, restore and enhance the productive capacities of existing peasant systems. In order to realize such potential the scientific-technical dimension of agroecology must remain the cornerstone for designing biodiverse, productive, and resilient farming system, which must obviously be implemented and disseminated by collective social action. As demonstrated in the past, creation of agroecological lighthouses and reviving traditional systems proved effective to widely spread successful local agroecological initiatives. In fact, most of the IALAs (Institutos LatinoAmericanos de Agroecologia-agroecological schools created by La Via Campesina in Latin America) contemplate the creation of a model farm as part of the technical training of their youth, through hands on demonstration modules. Although effective farming practices are important, agroecological principles rather than recipes are the pedagogical elements that should be spread via farmer-to-farmer strategies which crystallize in

redesigned farms. When a greater number of families adopt such systems via various training methods (learning from model farms, Campesino a Campesino, etc), reinforced by enabling policies and equitable markets, the scaling up of agroecology can lead to reconfiguring whole territories under agroecological management (Figure 2).

At times simple practices that give quick, visible results may appeal to farmers for early adoption, which has been the basis of the CAC methodology. However, the goal is to transition farmers to more complex practices and integrated systems. Although more complex agroecological management depends upon a more sophisticated understanding of ecological relationships, the lighthouses are a good model to unravel the complexity and focus more on the principles that underpin such systems rather than on the practices and technologies. Lighthouses feature examples of agroecological system redesign, which consists in the establishment of an ecological infrastructure that encourages ecological interactions through restoration of agricultural biodiversity at the field and landscape level. Well-designed biodiverse agroecosystems exhibit a number of synergies, which in turn lead to enhanced soil fertility, nutrient cycling and retention, water storage, pest/disease regulation,

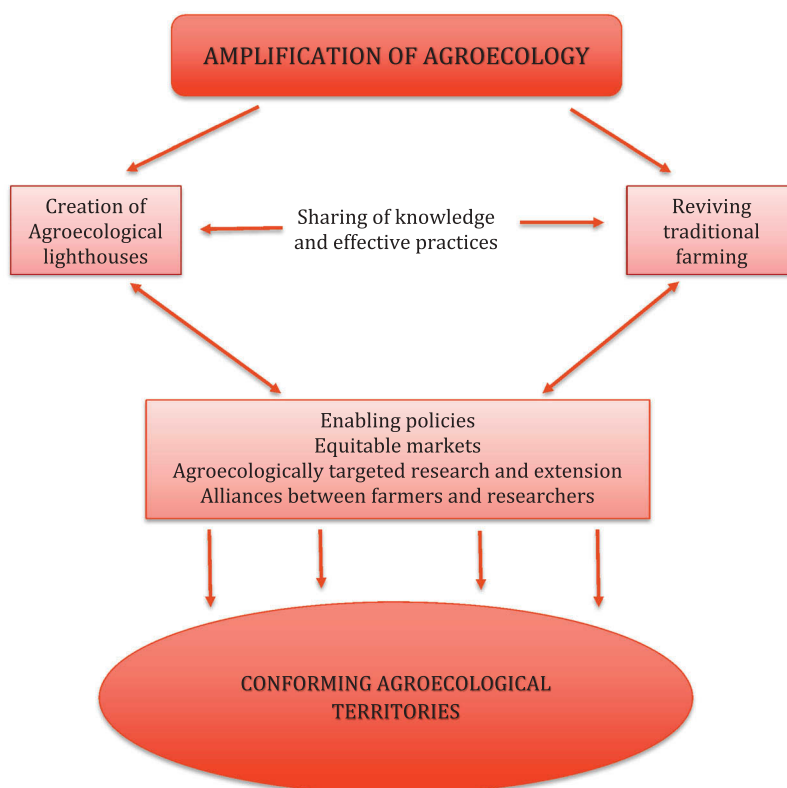


Figure 2. Pathways for the amplification of Agroecology: from the farm to the territorial level.

pollination, and other essential ecosystem services, without depending on external inputs, be they organic or conventional (Altieri, Nicholls, and Montalba 2017). These agroecologically re-designed farms constitute the basis for farmers' autonomy and sovereignty (Van Der Ploeg 2009).

To enhance the economic viability for the amplification of such agroecological initiatives equitable local and regional market opportunities should also be developed. Experience shows that policies can be supportive of the agroecological transition if they ensure that agroecological alternatives are adopted broadly, and that the resulting production finds guaranteed outlets in local or social markets. Particular emphasis must be given to the active participation of farmers in the process of technological innovation and dissemination through Campesino a Campesino models and lighthouses that focus on sharing experiences, strengthening local innovation and problem-solving capacities.

The creation of coalitions that can rapidly foster dissemination of agroecology among farmers, civil society organizations (including consumers), as well as relevant and committed research organizations are needed. Transitioning towards agroecology for 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 (Rosset and Martínez-Torres 2012).

Funding

Part of this work was supported over the years by CSFund, SOCLA and GIAHS.

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