Agroecological Practices for Sustainable Agriculture

Principles, Applications, and Making the Transition

Editor

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Preface

"But what are agroecological practices?" This was the question, raised four years ago by my colleagues when we decided to create a new teaching module called "Agroecological Cropping Practices," within our international MSc Agroecology programme. Upon an initial search for definitions and clearer descriptions, we found that we could not adequately respond to this question. Attempting to define what agroecological practices could be, we conducted a thorough literature review and discussed with other colleagues and practitioners, their perspectives on which practices qualified as agroecological practices. Although during this initial step we limited ourselves to cropping practices under temperate climates, it still remained a significant and time-consuming effort to evaluate, define, and summarise the breadth of agroecological practices included in this first paper.

In the years since our initial effort, other authors have evaluated and discussed the criteria for agroecological practices in cropping or livestock systems. As such, interesting recent advancements have emerged concerning definitions and developments of agroecological practices. Under the framework of agroecology, "practice" is considered one of the three major interpretations of the term agroecology, along with agroecology as a scientific discipline and as a movement. Each of these interpretations have a common goal: to develop and design sustainable agriculture and food systems. The question of which practices constitute agroecological practices is of great importance to farmers, professionals in agriculture,

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Chapter 8

Agroecology and Participatory Knowledge Production and Exchange as a Basis for Food System Change: The Case of the Community Agroecology Network

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1. Introduction

Food insecurity especially in the form of seasonal hunger is persistent in smallholder coffee growing communities in Mexico and Central America (Bacon *et al.* 2014). At the same time, industrialised agriculture has supplanted centuries-old traditional food systems and agricultural practices, resulting in ecological degradation, a weakening of local economies as

farmers become dependent on few cash crops, the loss of traditional environmental management knowledge, and families increasingly vulnerable to economic and ecological shocks (Gliessman 2015).

This chapter seeks to apply a model of agroecological transformation and change to evaluate the case study of a long-term partnership model between an international non-profit organisation, local organisations in Nicaragua and Mexico, and smallholder coffee farming families. The partnership model was based on agroecological principles, and utilised participatory action research (PAR) processes to jointly identify problems leading to food insecurity and vulnerability, formulate solutions rooted in local, existing knowledge and practices, and reflect on, evaluate, and adjust strategies together in annual iterations. The case study demonstrates how agroecology is a mutual, horizontal learning process among partners, and that it can reduce vulnerability among farmers who depend so much on a market commodity like coffee while ensuring food security. It also shows how the change process is an evolutionary process, not one of simple adoption.

2. Background: Smallholder coffee farmer vulnerability and agroecology as a solution

Food insecurity among smallholder coffee farmers is a common reality that has only recently been recognised, and it is still not well understood (Putnam and Brown 2013, Bacon *et al.* 2014). The most common manifestation of food insecurity among coffee smallholders is seasonal hunger, although transitory hunger also occurs as the result of ecological or economic shocks that affect a family's ability to access food (Bacon *et al.* 2014).

While access to markets and income generation tend to be high on the agendas of mainstream development organisations for alleviating food insecurity, smallholder coffee farmers solely dependent on one cash crop and the market face significant vulnerability for a number of reasons. First, volatile coffee markets combined with cyclical maize and beans markets often leave farmers facing high food prices when they are receiving low coffee prices. On top of this, climate variability has seen severe

droughts, inundations, and increased pest infestation affecting both food and coffee production, in turn impacting household access to food and income. Farmer cooperative organisations have played a role in mitigating the impacts of these factors by increasing access to assistance, securing higher or more stable prices for their members' coffee through specialty markets like fair trade or organic, but these have not proven to actually reduce smallholder coffee farmer vulnerability nor significantly enhance their livelihoods (Bacon 2004, Méndez *et al.* 2010). Second and related to the first challenge, is lack of broader access to specialty coffee markets, which can theoretically lead to reduced incentive for a farmer to invest in improving their soils.

A third factor impacting farmer vulnerability is a high rate of emigration at the household level, with no discernible difference seen among families benefitting from coffee certifications (Méndez *et al.* 2010). Emigration is especially common among young household members, who increasingly see coffee farming as an unviable livelihood. The exodus of young future farmers from the farming livelihood breaks down the social fabric of a community and in fact threatens the future of smallholder coffee production. A fourth factor exacerbating smallholder vulnerability is the ongoing shift away from traditional crops and varieties for household consumption and local trade, to cash crops for export (Ghosh 2010), combined with the influx of imported — and often highly processed foods into rural communities (Friedmann 2005). This trend has in turn led to the loss of traditional agricultural knowledge and practices and the subsequent weakening of the ecological integrity of the farming system as higher-impact practices, including chemical fertilisers, become more predominant. A secondary effect of this trend is a decrease in soil fertility and increased vulnerability of coffee and food crops to disease outbreaks.

The dominant response at the state level to the vulnerability of smallholder coffee farmers is production input or seed subsidies, even as some governments recognise that cookie-cutter recipes that are productivist in spirit are bound to be ineffective, and are exploring various forms of innovative farmer engagement, including the formation of local food security councils (Putnam *et al.* 2016). At the same time, international

development organisations have focused on production diversification for market as their main strategy to address smallholder vulnerability. But given the lack of understanding of the complexity of the causality of food insecurity and seasonal hunger in coffee growing communities, and the tendency to implement similar strategies in different contexts, questions remain as to how or if these strategies actually mitigate the diverse set of factors impacting household food security.

A long-term partnership model has sought to answer the question of how smallholder coffee farmers can utilise an agroecological approach to transform their food system and alleviate food insecurity and seasonal hunger. The Community Agroecology Network (CAN) is an international non-profit organisation committed to sustaining rural livelihoods and environments through collaborative research and action (Jaffe and Bacon 2008). It focuses on agroecological capacity-building and locally informed sustainable development strategies. It is a network of affiliated researchers, partner organisations, men and women farmers, and community youth leaders doing agroecology (see www.canunite.org).

CAN is committed to combining research and action for social change. CAN's action research initiatives study the interrelated problems of food security, rural outmigration, agricultural sustainability, and the lack of opportunities for young people in rural areas. CAN researchers partner with communities and local organisations to determine research agendas and methods so that research findings will be relevant and useful. We work together to jointly identify problems and potential solutions, monitor their implementation, reflect on their efficacy and challenges, and make adjustments in many iterations over time to "create agroecological landscapes" (Méndez *et al.* 2013). We recognise and value different ways of knowing, and promote intercultural exchange of knowledge and practices as a key tool to achieving food system transformation.

CAN works towards achieving food system sustainability, food security, and food sovereignty using three ideas or principles:

(i) Markets without household resiliency increase vulnerability
Resiliency means a household is able to confront ecological shocks (like floods, droughts, and infestations associated with climate change) and economic shocks (like cyclical commodity prices, as in the case of coffee). CAN has learned that household resiliency is achieved when families have diverse production for consumption and sale, not relying on one sole cash crop for income; this way, if one fails, the farmer and her family can rely on the rest. It has also become apparent that resiliency is strengthened with increased soil health where crops with adequate nutrition are robust and can resist pests, drought, and other extreme conditions that threaten a farmer's livelihood. Finally, resiliency is strengthened when the entire family is empowered as producers, consumers, and marketers of household production in the household economy — they have seen that when women have control over part or all of the household income, families have improved nutrition and food security.

(ii) Agroecology is a mutual learning process
It must include all stakeholder voices in a process where all ways of knowing — local, practical, academic, and professional — are valued equally as part of a larger toolbox wherein the farmer or community can choose what is most appropriate for their context, adapt practices to their own local conditions, and create their own culturally-specific toolbox from what is available. Similarly, to achieve maximum learning, it must be assured that women, men, and youth perspectives must be included throughout the process as distinct voices.

(iii) Agroecology enhances food security and sovereignty
While ecologically-sound production practices are at the core of agroecology, they are not viable without vibrant local food economies that foster fair market channels and farmer control of local food system resources, from seeds to the land. Agroecology improves soil health, water usage, pest and disease management, and the social relations of trade, ensuring robust food and cash crops, minimising pollution, enhancing biodiversity and multifunctional agrobiodiverse environments. The result is, diverse foods are reliably available at a lower cost to farmers without sacrificing their or their environment's health.

Putting these principles into place is not done by merely prescribing sets of agroecological practices or strategies that can be easily replicated. Instead, smallholder farming families and communities are engaged with CAN and local organisations in collaborative research processes that build capacity and identify solutions connected to their particular context and aspirations. Food security takes on an expanded meaning with agroecology, simultaneously emphasising availability, access, affordability, utilisation, stability, nutrition, social justice, and appropriateness (Putnam *et al.* 2014).

3. Engaging communities in a participatory learning process

The vulnerability of smallholder coffee farmers in Mexico and Central America became exceedingly clear during the coffee crisis of the early 2000s when coffee commodity market prices fell to their lowest levels in history, making the cost of growing and harvesting coffee higher than the price received (Bacon *et al.* 2008). CAN affiliated researchers working in these communities showed that income-based solutions (e.g. certified fair trade or organic premiums) do not reduce vulnerability. Even as prices picked up again, CAN found that farmers continued to face seasonal hunger and food insecurity. This was most serious during the "thin months" (*los meses de las vacas flacas*), a period of at least four months per year when people struggle to feed their families. People are paid for their coffee at the end of the harvest early in the year, but the income from this coffee usually runs out by May, when the rainy season begins and maize and beans are planted. Since they don't begin harvesting grain until August or September, the staple food grain market peaks at a time when this scarcity is most intense. Families often cannot afford to buy sufficient food given the high prices. The thin months from May to August are the inevitable result and when seasonal hunger occurs (Bacon *et al.* 2014).

A primary focus of CAN's work with smallholder coffee farmers and their communities is on improving food security and building food sovereignty (Figure 1). What this has led to over time has been a broad approach focused on creating healthy communities, vibrant local economies, and

Figure 1. A diverse multistoried coffee agroecosystem in northern Nicaragua. Apart from producing coffee for sale, this multifunctional system provides benefits ranging from food security to environmental services (photo: by Steve Gliessman).

landscapes where children experience improved nutrition and gain pride in their rural livelihoods, where youth and women play a stronger role in the creation of diverse household livelihoods, where diversification of coffee systems leads to improved soil fertility, and local people regain control over the availability of, and access to food in their communities.

Community engagement occurs through PAR (Bacon *et al.* 2005, Kingdon *et al.* 2007). PAR is an approach where researchers and non-researcher partners participate in an integrated, iterative, process of research (e.g. data collection), reflection (e.g. discussing findings), and action (e.g. using findings to resolve a problem), which leads to capacity building and ability to share experiences and learning with other communities. This mutual learning process means referring back to the roots of agroecology that were developed by early agroecologists observing and learning from farmers, trying things out together and communicating across knowledge systems that linked academic science and people's science (Gliessman 2016). PAR also means democratising knowledge production by making science work for the people. It focuses on

capacity-building with community partners, and eventually community mobilisers learn to conduct research in their own communities, and make data driven decisions for change for themselves. There is also a strong focus on sharing knowledge, where the learning together happens, both in terms of analysing the results of initial baseline studies and analysing the implementation of actions directed at resolving community-identified problems. Finally, a key part of the PAR cycle is action, when knowledge and experimentation is converted or adapted into changed agricultural practices, social structures, and economic activities that better address the challenges the community is facing. The most effective PAR projects are a continual cyclical process of knowledge exchange, experimentation, and innovation.

The basic steps for completing a successful PAR cycle by CAN for agroecology are the following:

Step 1. Work with partner organisations and their farmer members to identify needs, develop questions, and use a participatory approach to developing the initial baseline study;

Step 2. Train community promoters and youth leaders in data collection and analysis, then do the collection;

Step 3. Analysis of data and interpretation of results involving all stakeholders;

Step 4. Share results with communities in workshops to refine results and determine action plans based on participatory data gathering and review;

Step 5. Implement action plans.

Steps beyond: Monitor and evaluate results, compare to baseline study, share feedback on future actions, and make changes in action plans based on results of implemented strategies. PAR is an iterative process of sharing and reflecting how a particular strategy is going, how can it be better suited to community needs, and where all stakeholders are involved in a mutual learning process. After completing the first five steps in the PAR cycle, and implementation of action plans takes place, the cycle can repeat itself in the iterative process of linking research, reflection, and sharing of knowledge and experience.

4. CAN case study project: Youth leadership and food sovereignty in San Ramón, Nicaragua and Veracruz, Mexico

The Youth Leadership and Education for Sustainable Agriculture and Food Sovereignty Project was launched in 2011 as a collaborative initiative of CAN, the Union of Cooperatives, San Ramon (UCA, San Ramon) in Nicaragua, and the NGO Vinculación y Desarrollo Agroecológico en el Café (VIDA) in Mexico. The project aimed to build community-based climate change resiliency, alleviate food insecurity and seasonal hunger during the thin months, strengthen livelihoods among 234 coffee farming families, and build sustainable local food systems in 12 coffee-growing communities in Nicaragua and Mexico through education and the empowerment of local youth leaders and women in these cooperatives. The first phase of the project focused on the design of a participatory monitoring and evaluation system, implementation of a comprehensive baseline study of food insecurity and household livelihoods in the communities, the consolidation of the project's youth- and women-centred methodology and training of youth leaders, capacity building in agroecological food production, the establishment of homegardens, and reforestation with fruit, wood, and fuel trees. The second phase built upon these foundations and incorporated lessons learned from the first phase, by strengthening the focus on women's income generation, youth capacity building and leadership training, nutrition education, water access for consumption and irrigation during the dry season, soil health, access to quality seed, and access to staple foods during the thin months.

The beginning of Phase 2 in 2013, coincided with the onset of the crisis of the severe coffee rust disease known as the *la roya*, which was followed in 2014 by a two-year drought that severely impacted food production in Northern Nicaragua, and reduced rainfall levels from normal in Veracruz, Mexico. These compounding shocks clarified understanding of the positive mitigating effects of the strategies being promoted, and crystalised the vision of this project towards climate change resiliency and sustainable livelihoods. Food security and sovereignty align with this vision by sharing a focus on the empowerment of families and communities to ensure for themselves availability and access to food at all times of

year in any year. Similarly, the lens of climate change resiliency allowed everyone to look at the entire panorama of factors affecting food security — from climate to political structures to the quality of the soil. The project took a holistic approach to improving household climate change resiliency, food security, and livelihoods, seeking to promote personal empowerment of women and youth as change agents in their families and communities alongside increased access to and availability of basic and more diverse foods, income diversification for women and youth, nutrition education, improved water access for consumption and food production, and agroecological farming practices.

After going through the steps of the PAR cycle listed above, community/cooperative action plans were developed. Working with coffee farming families in eight communities and their cooperatives in San Ramón, Nicaragua, and four community groups in Veracruz, Mexico, the following action plans emerged. It is important to note that the action plans were considered to be living plans that left room for change response to emergent situations like drought, and to lessons learned along the way.

Action plan: Production diversification for household dietary diversity improvement and income diversification for women.

Diversification strategies included homegardens, diversification of coffee shade structure with fruit, wood, and fuel trees, diversification of patios with root and tuber crops, and diversification into protein (chicken and eggs) production (Figure 2). Women were the primary agents implementing these diversification strategies. The homegardens initially faced many challenges. First, many women stated that they did not know how to grow vegetables, as they "had not done this since their grandmother's time", as one woman stated. Basic capacity building led by trained local youth leaders commenced, focused on basic gardening and food production techniques, including seed selection, germination, transplanting, soil building and improvement technologies, and associative and rotational planting. After two years, most of the women felt comfortable and confident in their gardens and had even begun selling at monthly farmers markets or out of their homes.

A second challenge arose during the first growing season of the gardens. Through the annual survey, it was revealed that many families were

Figure 2. An example of the diversity of products being grown in homegarden agroecosystems in the community of Guzmantla, municipality of Ixhuatlan del Café, Veracruz, Mexico (photo: Heather Putnam).

not eating the food they were growing, instead they were feeding most of the vegetables to their pigs and other small livestock. In a follow-up workshop with the women gardeners, they informed us that they did not know many different ways to prepare the suddenly wide variety of vegetables available to them in their gardens. The action that followed was a series of nutrition workshops led by local women and youth in which traditional recipes were shared and tested with locally available plants, and the production of a cookbook of traditional and innovative recipes to promote dietary diversification. Another problem arose in the second year when it was learned that the women gardeners were either not saving seed or rootstock from their garden plants, or they were not able to save seed from certain plants like carrots or onions. A collective response to this problem was to refocus garden production on the plants whose seeds the women were able to save, especially plants that were locally traditional. An additional response was to train the women and youth in household seed saving techniques for vegetable and fruit seed and reproductive material.

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In the years that followed, families also developed a vibrant informal seed exchange system within and among communities. When it was found that there was no existing formal market for the vegetables produced in the homegardens, the cooperatives developed regular monthly farmers markets in the nearby municipal centre of San Ramon, and a group of women established and ran a café to sell directly to consumers coffee drinks prepared from their own coffee, and excess vegetables and fruits from the homegardens associated with the project.

Action plan: Relocalise access to staple foods (grain and seed)

The initial diagnostic study in 2011 revealed two troubling trends. First, families often had to purchase maize and bean (and sometimes sorghum for animal feed) during the thin months when the price of food was highest and when their income from the previous coffee harvest had already run out. This meant that some families could not purchase maize and beans, and resorted to eating cheap but less nutritious foods like boiled bananas. Even if they did have the money to purchase grain, they often had to buy it from middlemen or go into the city to buy it as there was no local distribution facility, adding even more cost to the food. Second, it was found that families often resorted to eating their seed put aside for the next season, which meant that they were unable to replant unless they bought more seed, resulting in a vicious cycle where access to basic foods became worse. A cooperative response to this problem of a lack of local access to staple food and seed for staple food, was the establishment of grain banks and seedbanks. This resulted in a total of seven grain and seedbanks in San Ramon, Nicaragua, and five seedbanks in Veracruz, Mexico, focusing primarily on maize and beans. The banks were led by elected commissions who were trained in their management and administration, and who subsequently led efforts to produce grain and seed for the banks, to make more available to the wider community. It is a prime example of collective action and social structure finding solutions to a systemic problem by creating a new system parallel to the existing system.

Action plan: Alternative market development for export coffee

Through the formation of a collaborative marketing process that involved the key stakeholders of a much shortened coffee commodity chain, CAN

has developed a branded agroecological coffee called AgroEco® Coffee. This has involved building an alternative market that is focused on agroecological production. It is not a certification, but rather a commitment to transitioning from the industrial monoculture model of production to an agroecological model. It also involves consumer education so coffee drinkers make conscious choices when buying their coffee, and including everyone in the commodity chain of coffee, from the farmers, their cooperative, the exporter, the roaster, and the researchers make at the negotiating table when the price for the coffee is being set each year. For the 2013/2014 harvest, this moved more than 12,000 kg of coffee beans from the farmers in Nicaragua to consumers, and 4,800 kg of coffee from Mexico.

Farmers received a base price for their coffee that exceeded even the premium given for fair trade and organically certified coffee. In addition to this higher return to the farmer, an additional 5% of the price paid by the coffee roaster contributes to a "Sustainable Agriculture Fund" to directly support the transition process by funding coffee innovation projects decided upon by the communities themselves. As an example, in one case growers in one cooperative knew that building organic soil fertility was a major issue, and considered supporting a composting project to produce compost from local resources. CAN and the community faced a very challenging moment with this project. Farmers, who are mostly men, with very low participation by women, are very risk averse. Despite doing farmer to farmer exchanges with farmers from communities that were already engaged in similar soil building projects, they were still hesitant. They were also facing another crisis — the outbreak of the coffee rust disease that was killing a large percentage of their coffee plants. To choose a different course of action to the conventional high-input model was seen as very difficult.

At the same time CAN, the UCA San Ramon, and VIDA wanted to strengthen women's access to capital. Progress had been made with the homegardens and farmers markets directed primarily at women, but it was evident that women were contributing more labour to coffee production (and other agricultural and household labour) than they were being compensated for. At the bargaining table, with buyer, importer, cooperative leaders, CAN, and men and women farmers all present, a second fund was

created, the Women's Unpaid Labour Fund, which added another 4% to the price of the coffee to be invested in an economic incentive initiative decided and controlled by the women themselves. Something interesting happened in Nicaragua. The women's group stepped forward and decided to invest their fund in the agroecological renovation of 0.5 hectares each in their family coffee parcels. Since then, the women have expanded their agroecological coffee plots to a little over a total of 10 hectares, and men and women gather every other Saturday to make organic fertilisers collectively to support their ongoing agroecological coffee renovation. And in Mexico, the women's group decided to invest their 4% in the development of a branded coffee they call FEMCAFE, and will be selling it locally and in other specialty markets in Mexico.

Action plan: Improve coffee agroecosystems with agroecological practices

After the hesitation to the compost plan, CAN researchers, youth leaders, and cooperative extensionists in Nicaragua convinced the whole group to invest the sustainable agriculture fund in buying natural materials and inputs (raw flour, molasses, rock minerals, etc.) for making artisanal fertilisers, as well as materials to make foliar sprays from culturing fungi in leaf litter from the mountains above their communities for disease suppression. At a calculated cost of about one tenth of conventional fungicides and fertilisers, the coffee plants are showing recovery from the disease outbreak and resistance to it from new plants. The efficacy of these agroecological soil health and plant nutrition techniques became evident after one year of application to vegetable gardens and to coffee being replanted with seedlings: the plants were robust and even starting to fruit after only 17 months in the ground. CAN and the UCA San Ramon then facilitated a process of horizontal exchange so that the other seven cooperatives engaged in the project could learn the same techniques. The learning exchanges included capacity building in the elaboration of nine different soil and foliar applications, including compost, worm compost, effective microorganisms, biofertilisers, and mineral foliar applications for both food and coffee production areas. Investments were made in barrels and other equipment to allow groups to produce the fertilisers and preparations collectively where appropriate.

A similar process unfolded in the Central Highlands of Veracruz, Mexico where CAN researchers and VIDA performed a full diagnosis of the impact of *la roya* on the coffee parcels of 151 farmers in 2014, as well as an inventory of agroecological practices already being used. They subsequently identified 12 soil fertility improvement applications and other agroecological techniques including mineral foliar sprays, and began implementing farmer-to-farmer learning exchange workshops. Since *la roya* fully hit the Veracruz region approximately 18 months after it hit Nicaragua, farmers are still in the process of recovering and are currently (as of January 2016) implementing renovation efforts accompanied by the implementation of agroecological soil building and plant nutrition practices to ensure the seedlings are robust and resilient against the rust and other infestations like anthracnose.

The process of "doing" agroecology in these communities has come full circle, yet continues to move round the iterative PAR spiral of development and action. This case study is an example of how and why to incorporate the multiple aspects and stakeholders of the food system in a change process. It links aspects such as household nutrition, local food production, building alternative markets (locally and globally), diversification, improving natural soil fertility, and empowering community members as agents of agroecological change. It also links change across all the five Levels of transformative food system change presented by Gliessman (2015, 2016) and presented in Table 1.

4. The five levels of agroecological change

Agroecology is a way of redesigning food systems, from the farm to the table, with a goal of achieving ecological, economic, and social sustainability. Through transdisciplinary, participatory, and change-oriented research and action (Méndez *et al.* 2013), agroecology links together science, practice and movements (Wezel *et al.* 2009, Gliessman 2015) focused on social change. But what are the steps that must be taken to transform food systems toward the ultimate goal of sustainability, and away from the mounting evidence of the negative impacts on the environment and society caused by modern industrial agriculture and purely commercial food systems?

Table 1. The levels of transition and the integration of the three components of Agroecology (i.e. science, practice, and movements for social change) needed for the transformation to a sustainable global food system. Adapted from Gliessman (2015, 2016).

Level	Scale	Role of agroecology's three aspects		
		Agroecological research	Farmer practice and collaboration	Social change
1 Increase efficiency of industrial practices, while lessening their environmental impacts.	Farm	*Primary*	*Important* Lowers costs and lessens environmental impacts	*Minor*
2 Substitute alternative agroecological practices and inputs.	Farm	*Primary*	*Important* Supports shift to alternative practices	*Minor*
3 Redesign whole agroecosystems.	Farm, region	*Primary* Develops indicators of sustainability	*Important* Builds true sustainability at the farm scale	*Important* Builds enterprise viability and societal support
4 Re-establish connections between growers and eaters, develop alternative food networks.	Local, regional, national	*Supportive* Interdisciplinary research provides evidence for need for change and viability of alternatives	*Important* Forms direct and supportive relationships	*Primary* Economies restructured; values and behaviours changed
5 Rebuild food systems globally so that they are sustainable and equitable for all.	Local to global	*Supportive* Transdisciplinary research and action promotes the change process and monitors sustainability	*Important* Offers the practical basis for the needed paradigm shift	*Primary* Food systems fundamentally transformed

The case study presented in this chapter also requires specific theories of transition to be drawn upon, both in regard to broader political transitions, and to the particular set of factors surrounding agroecological transitions. In particular, the present case study can be analysed with reference to the *five levels of change* identified by Gliessman (2015, 2016). The change process is not necessarily linear, since it depends on the starting point for each agroecosystem and the confluence of factors, issues, and histories faced. It also depends on the scale of food system operation, from a local farm to the global food system, or if the farm is located in a developing country where smallholder farms are the norm versus developed countries where simplified large-scale monoculture farms have often become the norm (Gliessman 2015). At each level of change, agroecological research contributes to changing farming practice and the development of important indicators of change. Farmer experimentation, practice, and collaboration are key to promoting innovation, understanding, and value shifts. Consumer understanding and wider social support for alternative food systems are also essential elements in supporting change. Finally, a supportive policy environment is vital for incentivising, and even regulating, a true paradigm shift in food and agriculture systems.

These factors correspond to the different levels of change. The first three levels describe the steps farmers can actually take on their farms for converting from industrial or conventional agroecosystems. Two additional levels go beyond the farm to the broader food system and the societies in which they are embedded. The five levels taken together are used in this chapter to assess and evaluate the progress the case study presented here is making towards the transformation to sustainable food systems, as well as pointing out key areas for promoting further reform. The five levels of change are described as follows and summarised in Table 1:

Level 1. *Increase the efficiency of industrial/conventional practices in order to reduce the use and consumption of costly, scarce, or environmentally damaging inputs.*

The primary goal of change at this level is to use industrial inputs more efficiently so that fewer inputs will be needed and the negative impacts of their use will also be reduced. Most conventional agricultural research has taken place at this level, through which considerable modern agricultural

technologies, inputs, and practices have been developed. This research has helped farmers maintain or increase production through practices such as improved seeds, optimum planting density, more efficient pesticide and fertiliser application, and more precise use of water. So-called "precision agriculture" is a recent focus of research at Level 1. Although this kind of research has reduced some of the negative impacts of industrial agriculture, they do not help break its dependence on external human inputs and monoculture practices.

Level 2. *Substitute alternative practices for industrial/conventional inputs and practices.*

The goal of this level of transition is to replace external input-intensive and environmentally-degrading products and practices with those that are more renewable, based on natural-products, and more environmentally sound. Organic and bio-dynamic agriculture are examples of this approach. They employ alternative practices that include the use of nitrogen-fixing cover crops and rotations to replace synthetic nitrogen fertilisers, the use of natural controls of pests and diseases, and the use of organic composts for fertility and soil organic matter management. However, at this level, the basic agroecosystem is not usually altered from its more simplified form, hence many of the same problems that occur in industrial systems also occur in those with input substitution.

Level 3. *Redesign the agroecosystem so that it functions on the basis of a new set of ecological processes.*

At this level, fundamental changes in overall system design eliminate the root causes of many of the problems that continue to persist at Levels 1 and 2. The focus is on prevention of problems before they occur, rather than trying to control them after they happen. Research on whole-system conversions has provided an understanding of key yield-limiting factors. Agroecosystem structure and function is better understood, and appropriate changes in design can be implemented. Problems are recognised, adjustments made in internal site- and time-specific design and management approaches, instead of solely by the applications of external inputs. A good example is the reintroduction of diversity in farm structure and

management through such actions as ecologically-based rotations, multiple cropping, agroforestry, and the integration of animals with crops.

Level 4. *Re-establish a more direct connection between those who grow food and those who consume it.*

Food system transformation occurs within a cultural and economic context, and this transformation must promote the transition to more sustainable practices. At a local level, this means those who eat must value food that is locally grown and processed, and support with their food dollars, the farmers who are attempting to move through Levels 1–3. This support becomes a kind of "food citizenship" and can be seen as a force for food system change. Communities of growers and eaters can form alternative food networks around the world where a new culture and economy of food system sustainability is being built. Food once again must be grounded in direct relationships. An important example is the current food "re-localisation" movement, with its growing networks of farmers' markets, community supported agriculture schemes, consumer cooperatives, and other more direct marketing arrangements that shorten the food chain.

Level 5. *On the foundation created by the sustainable farm-scale agroecosystems achieved at Level 3, and the new relationships of sustainability of Level 4, build a new global food system, based on equity, participation, democracy, and justice, that is not only sustainable but helps restore and protects earth's life support systems that we all depend upon.*

By thinking beyond Levels 1–4, Level 5 involves change that extends from local to global and reaches beyond the food system to the nature of human culture, civilisation, progress, and development. The depth of change is more than mere conversion or transition, and enters into the realm of full reform or transformation. With Level 5 thinking and action, agroecology provides ways to build upon farm-scale and farmer-driven change processes to a full rethinking of how we all relate to each other and to the earth that supports us. Basic beliefs, values, and ethical systems change. The expanding awareness that is part of this process, then extends to other facets of environmental and social relationships beyond food, bringing about a paradigm shift focused on how the agriculture and food

systems of the future can help reduce our ecological footprint, recognise that there are limits to growth, and what it really means to live sustainably. The important role that food systems can and must play in mitigating and adapting to climate change as a global issue is one example of the value of Level 5 thinking. The growing food justice movement, where everyone in the food system enjoys the benefits of equity, justice, security, sovereignty, and sustainability, is another.

What will food systems look like when Level 5 thinking and action guides the changes that need to take place? What are the incentives needed to stimulate these changes? Can this thinking bring about essential changes in policy, support systems, funding, and choice? Is the change process actually a stepwise, longitudinal one, starting at Level 1 and ending with Level 5, or should Level 5 thinking determine where the process begins depending on where the farmer or the food system is at the moment. The five levels of practice and action for change provide a very useful framework for guiding and evaluating this transformational process.

5. Evaluation of the community-based CAN case study

Has CAN's partnership model with these communities made a difference? Has the needle on food security and sustainability been moved? Some answers can be found in Tables 2 and 3.

6. Discussion and evaluation of the change process

After five years of participatory interaction, learning, and monitoring, agroecology in the partner communities of San Ramon, Nicaragua and Veracruz, Mexico has moved the needle of change in several important ways. Most importantly, it has reduced the "thin months" considerably. Ideally, the goal is to eliminate them completely. Using the *five levels of change* framework, it would appear that the change process is still in its early stages. What began as a project focused on improving the coffee production systems and finding alternative markets that provided a better price for the coffee, mainly as a response to the coffee crisis of the early 2000s, was forced to expand its focus with the outbreak of the coffee rust

Table 2. Summary of selected components of food system change ranked using the "five levels of change" in coffee growing communities in the region of San Ramón, Nicaragua, and Veracruz, Mexico. Data based on 95 households in San Ramón and 135 households in Veracruz, and are the cumulative outputs from 2011–2015 as reported in Putnam *et al.* 2016 and the final project report to Keurig Green Mountain (CAN 2015b).[1]

Selected outputs of food system change	San Ramon, Nicaragua	Veracruz. Mexico
Level 1		
Number of households with garden irrigation systems installed	35	3
Number of water catchment systems installed	9	46
Level 2		
Number of soil fertility and conservation practices implemented[2]	9	13
Number of households adopting Best Agricultural Practices[3] promoted by the project	95	139
Level 3		
Number of wood, fuel, or fruit tree seedlings planted in the community	28,403	2,995
Number of fruit trees planted	5,560	1,875
Number of households diversifying with fruit trees and vine crops, and vegetable crops	95	135
Number of species of heirloom vegetable seed being saved by households	20	18
Area for diversified vegetable production in homegardens or patios in manzanas[4] per household	0.73	—
Level 4		
Percent of households consuming more than six food groups daily over period 2013–2015 (%)	82–100	84–100
Number of food storage and distribution centers (CADA[5]) at a cooperative serving 200 families	7	0
Pounds of maize and beans distributed as food by CADAs	beans: 2415 maize: 2400	0
Number households with functioning homegardens	95	139
Number of farmers markets 2011–2015	21	25

(*Continued*)

Table 2. (*Continued*)

Selected outputs of food system change	San Ramon, Nicaragua	Veracruz. Mexico
Level 5		
Community Seedbanks[6] at a cooperative serving 100 families	7	5
Pounds of corn and bean seed distributed for planting	6600	300
Number of home water filters installed and in use	40	44
Number of home chicken coops constructed	62	94
Number of value added rural enterprises for women or youth established	2	5
Number of women selling in rural enterprises and markets	30	59
Number of youth selling in rural enterprises and markets	10	31
Number of youth leaders participating in project activities	12	8
Number of school gardens functioning and supported by youth leaders	3	3
Number of community or cooperative-based commissions functioning and running food security and sovereignty infrastructure	7	4
Number of community workshops, trainings and exchanges in 2015	16	44

[1] Data for 95 households in San Ramon and 139 households in Veracruz. In most outputs the initial value was at or close to zero.
[2] For example, cover cropping, composting, reduced tillage, etc.
[3] Based on community-based experiences developed by CAN (2015a).
[4] In Nicaragua, approximately 0.7 ha or ~7000 m^2.
[5] CADAs (Spanish acronym) are Food Storage (especially maize and bean grain for consumption) and distribution centres of basic household goods purchased in bulk and housed at the cooperative for cooperative members at a reduced price.
[6] Community Seed banks are part of CADA's, where local seeds for planting are properly stored and made available to cooperative members through a 2:1 exchange and return system.

intensive production of coffee to alternative, agroecologically-based best practices.

Simultaneously, work at Level 4 focused on linking coffee farmers with coffee drinkers, both locally and on the international market. A more

Table 3. Quantitative impacts of change over the five years of collaboration in eight cooperatives and their communities in San Ramón, Nicaragua and four communities in Veracruz, Mexico. Based on 95 households in Nicaragua and 139 households in Mexico.

Indicators of Change	2011	2012	2013	2014	2015
San Ramón					
Months of adequate provisioning	7.4	7.3	8.1	9.8	9.7
Length of "thin months"	4.6	4.7	3.9	2.2	2.3
Dietary diversity score[1]	—	6.6	7.8	7.1	7.4
Percent of households consuming more than 6 food groups daily	12	83	100	83[2]	82[2]
Coping strategies index (CSI)[3]	16.8	11.0	17.5	15.1	8.1
Veracruz					
Months of adequate provisioning	—	10	10	9	10
Length of "thin months"	—	2	2	3	2
Dietary diversity score	—	6.9	6.9	7.3	8.5
Percent of households consuming more than six food groups daily	—	100	84	94	100
Coping strategies index	—	20.0	24.4	9.3	4.4

[1] Dietary diversity scores based on the number of food groups consumed during a given time period, with 12 food groups used as a foundation (based on methods reported in Swindale and Bilinsky (2006)).
[2] These slightly lower numbers can be explained by the drought, which affected some families in the sample who had less access to water to irrigate their gardens.
[3] CSI = Coping Strategies Index = this score measures the variety of behaviours that people implement to cope with scarcity. Lower score means the usage of less severe strategies or less frequency use of strategies, hence less scarcity. Strategies based on activities described in Levels 1–4.

disease that devastated coffee production beginning in 2012. What had begun primarily as a project focused on moving farmers from Level 1 to Levels 2 and 3, quickly pushed beyond to Levels 4 and 5. Early on, multiple important steps were initially taken to transition conventional, input

just and democratic process for setting the price of coffee to the growers was established, grounded as much in shortening the commodity chain as it was on bringing all of the voices to the table during price negotiations. But is also was clear that the market for coffee was not the only answer. The coffee crisis of the early 2000s had made it very clear that coffee farmers and coffee growing communities were the most vulnerable when prices fell, and that informed and conscious consumers and roasters operating at Level 5 in their awareness of the injustices and inequalities that the market imposed were needed to make change happen.

By the time the project began in 2010, CAN had already established a close relationship with the farmers, their communities, and the cooperatives to which the farmers belonged. Levels 3, 4, and 5 began to interact together as the need to reduce the thin months became a primary goal. Diversification of the farms was the Level 3 component, which provided additional food for local consumption. But income to support vibrant local livelihoods could only come about at Levels 4 and 5. Home gardens, for example, diversified the farm landscape at Level 3 (Tables 2 and 3), but farmers, most of whom were women, needed the help and incentive of Level 4 mark*et al*ternatives in order to expand their use and diversification. Local farmers markets, exchange within their communities, and the reduction in the need to purchase food have all been coming together.

It is at Level 5, however, where longer-term, more permanent change comes about. Creating opportunity for women to take the lead, and be rewarded, in livelihood diversification, be it installing a homegarden, planting women-managed coffee plots, or building a café and farm store in a nearby urban centre, required a change in culture and custom. There is a story to tell behind this process, with beliefs, values, and actions taking place at Level 5 making it happen. There is also a story to tell about how until some of the Level 5 changes occurred, many of the changes that happened at Levels 3 and 4 would have never been possible. School gardens, youth leadership training, creating awareness of local food customs, expanding understanding of opportunities and needs in communities, and local youth becoming leaders in local projects and other activities that provide options for staying in their communities and becoming part of the

change process, are all Level 5 actions that promote and encourage change at all levels in the system.

CAN has been a partner in this change process, operating from a Level 5 perspective that change could occur, and it could result in a major paradigm shift from the very beginning. But rather than push this approach on the communities it was working with, an open, participatory approach was used from the beginning. As agroecologists, CAN researchers had an understanding of sustainability and alternative farming practices and designs. As farmers, the community members had generations of farming experience and local understanding of their environment. These "ways of knowing" came together in the transdisciplinary respect for each other's knowledge and experience. Through broad participation, transparency and trust developed. Experiments were initiated. Observations and monitoring were done jointly, and local capacity among youth to both take data and analyse it was carried out. Findings were shared, discussed, and used to take new steps, try alternative management practices (Level 2), and begin diversifying and redesigning their farms (Level 3). As results (both positive and negative) were generated, more ownership for the change process began to appear as well. This is probably most commonly called "empowerment", and has begun taking place in all members of the communities — men, women, and youth (Level 5).

This "ownership" of the change process is too often very slow to come about. With the 5 Levels of change process, it can happen. An organisation like CAN will not be able to accompany the change process in the communities it works with forever. Eventually, the communities must guide it themselves. But getting fully to Level 5 is a challenging process, with resistance to change all too common. When we do, the paradigm shifts. The local social organisations, capacity building, and sharing of knowledge across social networks then come together to form the resilience rural smallholder communities need. This case study is intended to demonstrate how CAN's approach to agroecology is a mutual learning process with community partners, and that it can reduce vulnerability among farmers who depend so much on a market commodity like coffee while ensuring food security. It also shows how the change process is an evolutionary process, not one of simple adoption.

As a farmer said during an exchange about halfway through this 5-year project:

> "When you first came to our community, you said that we had in our own hands what we needed to change. We did not understand what you meant at that time. But now we do. And we are making the change happen." (Don Pedro, La Pita)

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Chapter 9

Assessing the Impact of Management Interventions in Agroecological and Conventional Cropping Systems Using Indicators of Sustainability

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1. Introduction

There is an increasing pressure on the agricultural industry to provide large quantities of high quality food while maintaining or improving environmental and ecological sustainability. The intensification of agricultural production since the 1950s has resulted in increases in yield, but only at heavy environmental cost: increased greenhouse gas emissions, increased water pollution through loss of agro-chemicals from fields, loss of arable plant and animal biodiversity with negative effects on ecosystem function and services, and degraded physical structure of the soil causing soil erosion and compaction.