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# Social-Ecological Resilience and Maize Farming in Chiapas, Mexico

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## 1. Introduction

Chiapas is considered one of the areas of origin for maize, and indigenous production systems remain a major element of maize farming and the food system of Mexico's southernmost state. These traditional systems often include a complex, long-term relationship between maize farming and the larger landscape (Medellín and Equihua, 1998). However, what often appear to be static, steady states of small farmer land use in fact are highly dynamic systems that are in the midst of major adaptations to new climatic and economic conditions. The globalization of the agribusiness model that came to dominate the U.S. landscape during the 20th century has put intense pressures on small farmers in Chiapas, adding to complications arising from shifting growing seasons and other effects of global climate change. However, history has shown that Mexican small farmers are never passive objects of their circumstances, and their responses to early 21st century marginalization take both centralized and local forms, in political and productive terms (Guevara-Hernández et al. 2011a). The balance of forces—capitalist agriculture, external input dependence, neoliberal national food policy on one hand; traditional knowledge, agroecological transitions, social movements on the other—in Mexican agriculture tends to distinguish two contending models for food systems, even as climate change, resource scarcity, and economic crises limit humanity's options.

Shifting cultivation and other traditional systems of food production in Chiapas are being highly influenced by the slow-motion arrival of industrial agriculture, which is based on maximizing short-term productivity through the use of synthetic inputs such as fertilizers and pesticides, as well as commercial seeds (Garcia-Barrios et al. 2010). Most farm inputs are supplied by Mexican subsidiaries of foreign-owned multinational corporations such as

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Monsanto, Syngenta, and Dow. At the same time, an industrial food system means that large amounts of capital are invested in food sales, creating giant monopolies in processing and distribution, which significantly reduce the portion that farmers receive of the price paid by consumers. In other words, control over the food system—the set of activities that are built around capital flow and labor command in food production, shipping, transformation, consumption—is highly concentrated in the hands of input manufacturers and food processing, trading, and retail corporations, while the riskiest part of agriculture—the actual farming process—is still in the hands of hundreds of thousands of small farmers (Magdoff et al. 2000).

In Chiapas, these farmers live in hills and valleys, in forested land and former forests, in dry shrub lands and in lush jungles. Their communities and farmlands compose a peasant landscape, in which patches of forest are interspersed in a complex mosaic of farms, backyards, homes, schools, rivers, roads, and towns. Depending on the type of agriculture practiced, soil may be highly degraded or intact. Chiapas is a center for biodiversity; many endemic species live in and around forest patches and agroecosystems (Ramírez-Marcial et al. 2001). In this setting, the demands of rural social movements such as *¡Sin Maíz No Hay País!* (Without Corn There is No Country!) increasingly refer to the goal of food sovereignty. Food sovereignty means a fundamental emphasis on local and domestic production, based on land access for small farmers and ecological production practices. It rejects food as a commodity to be included in free trade agreements or dumping schemes meant to undermine countries' domestic production capacity. As a political proposal, food sovereignty implies a radical democratization and decentralization of the agriculture-food system, including the destruction of corporate power over food. On a more cultural level, food sovereignty is an affirmation of rural community, local knowledge, and gender equality.

Both the agribusiness model and the food sovereignty model are highly complex, integrated systems that involve the relationship of society and nature. The stability of each system depends on distinct factors that combine social and ecological drivers, while the capacity of each to respond to shock or disturbance will depend on unique intrinsic qualities. In the case of industrial or export-focused agriculture, we have a system that has been shown to be destructive to peoples and ecosystems, due to its focus on short-term profits through maximizing monoculture productivity. Here we draw from theoretical contributions from restoration ecology that use models of alternative stable states to study change in complex systems (Suding et al. 2004). We argue that monoculture/capitalist agribusiness represents one pull of attraction, or alternative state, indeed a food system unique to late-stage global capitalism. On the other hand, we propose that the agroecology/food sovereignty framework may in fact represent another alternative state, far more promising for building resilient food systems in the 21st century. In order to develop this line of inquiry, we start by examining more closely the resilience paradigm and the two proposed stable states at an abstract/global level. Then we describe historical, agroecological, and political elements of food system resilience in the case of a maize-growing community in Chiapas.

## 2. The resilience paradigm

Research into sustainable agriculture has increasing come to embrace the conceptual approach of food systems, as these reflect the interface of alimentation, human activities, public policies, cultural norms and social well-being, along with land, farms, ecosystems, and economies. The complex interactions between these processes at distinct scales, and involving various institutional and economic actors, may produce the outcome of food security. The food system approach may be useful for developing cohesive strategies across policy sectors, including agrarian and land access sectors, natural resource and environmental management, agriculture, trade, economy, industry, science and technology, health, and education, among others (Ericksen et al. 2010). Efforts to achieve food system sustainability in the midst of global environmental and economic changes are beginning to coalesce around certain concepts that help determine the most significant problems in food systems and identify management strategies at several levels of analysis (farm, community, national, international) to increase social, ecological, and economic sustainability (Pretty et al. 2011).

The management of complex, adaptive systems has become a dynamic field of new trans-disciplinary theory, especially with regard to life supporting systems of human activities, such as agriculture, in sensitive ecological contexts. Social-ecological systems (Berkes and Folke, 1998), or coupled human and natural systems (Liu et al. 2007), have become a central concept to allow greater understanding of the interdependencies and feedbacks between social and ecological systems. The contributions of systems ecology are applied in order to understand the complex internal dynamics and adaptability of these coupled systems. Many of the concepts that inform such studies of systems originate from ecology, for two reasons: one, its emphasis on qualities that emerge from a set of relationships between elements, rather than the reductionist focus on elements in isolation; and two, the growing academic and popular concern for the relationship between humanity and the biosphere that tenderly exists on the surface of the Earth's crust (Lang, 2009).

In the efforts to understand the intrinsic qualities of social-ecological systems, researchers from several different disciplinary backgrounds have approached the concept of resilience (Shattuck, 2012). The resilience principle stems from systems ecology theory (Hooper, 1973) that suggested that instead of static, unchanging climax communities, natural ecosystems could evolve between several alternative stable states, with biotic and abiotic feedback mechanisms accelerating or preventing system change. Disturbances began to be seen as an integral part of ecosystem function, and resilience as an emergent system capacity to absorb a certain magnitude of shock and maintain key system functions before reaching a critical threshold and switching to an alternative stable equilibrium with new system properties (Holling, 1973; Noy-Meir, 1975). Noy-Meir (1975) used the analogy of a mechanical ball-in-container (figure 1) to describe alternative steady-states. The original steady-state is stable to fluctuations within a certain range, but too hard a push in one direction will send it over the turning point and toward a new steady-state. The major concern in light of global environmental change is that ecosystems will be pushed beyond their limits, into new steady-states that provide less ecological services (Walker et al. 2004).

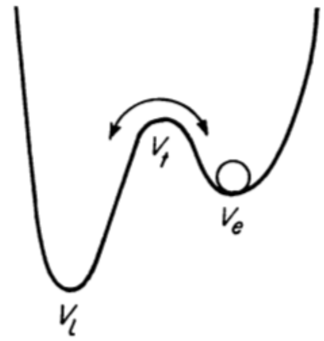

**Figure 1.** A physical model of the two-steady-states situation (from Noy-Meir, 1975).

The two-steady-state model is a very simple illustration of a key concept in resilience studies: the threshold. The high point of the center curve in figure one is the threshold, or point of no return, for the original system. Resilience systems may absorb strong shocks below this point; one tiny push above it will result in what could be irreversible and accelerated change. One of the major objectives of resilience research is to identify and characterize system thresholds, in order to understand what makes systems able to absorb some shocks without changing overall function, what makes some changes temporary and others permanent, and how to shift thresholds through system adaptations. Social and ecological dynamics in industrial food states can be very different from dynamics in traditional or sovereign food states. Efforts to promote transition to a sovereign food state need to better understand feedbacks and constraints of the industrial food state. Alternative state models, used in restoration ecology to focus on internally reinforced states and recovery thresholds (Suding et al. 2004), may help guide historic conversions to sovereign food systems.

The recent attention paid in academic literature toward the concepts of risk, robustness and resilience in social and economic systems is surely related to such troubling events as the global financial crisis of 2008; the Great Recession that is still very much limiting employment and well-being among most nations in the world; the so-called Arab Spring that has produced protest movements for systemic change in diverse countries like Egypt, Tunisia, Yemen, Libya, Syria, Spain, Greece, Portugal, France, and the United States; the global food price crises of 2007 and 2011; the impending scarcity of hydrological and energetic resources; and finally, the arrival of such damning evidence as increased incidence of extreme weather events (e.g. hurricanes, droughts, floods) and long-term changes associated with excessive greenhouse gases in the Earth's atmosphere.

The sudden growth in use of the term "resilience" has been studied elsewhere and associated with a shift toward the understanding of complex systems as being more dynamic and less tied to any one climax or stable state. The Resilience Alliance and the Stockholm Resilience Centre, high-profile scientific platforms that bring together orthodox neoliberal economists with systems ecologists (Walker and Cooper, 2011), emphasize an adaptive cycle within complex systems that includes phases of growth, decadence, self-destruction and renewal. Curiously, this self-organization that complex systems are seen to have is used to argue against inserting planning mechanisms and regulation on economic systems. Indeed, the free market is argued to be a complex system capable of self-regulation. The same analysis considers the shock of deregulation and structural adjustment programs to be a healthy opportunity for renewal. A skeptic might insert here the example of New Orleans or Iraq, both places where disaster (to be located somewhere on a gradient between "natural" and human-made) created an opportunity to rebuild in a new image and for the benefit of a distinct group, in both cases resulting in massive profits for contractors that, incidentally, worked under U.S. government contact (i.e., the planned economy). Essentially, orthodox neoliberals create conditions for huge profit by monopoly capital, rather than constructing any sort of self-organized or resilient world state. On the contrary, we argue that the resilience of a local food system is often inversely related to its integration into the world capitalist economy.

Shattuck (2012) proposes a framework for studying resilience in food systems, in order to effectively prioritize goals of human well-being and biodiversity conservation. This author combines literature on biophysical restraints, adaptive capacity, and political economy to develop a food system resilience framework that considers ecological processes and underlying macroeconomic causes of livelihood vulnerability. Here we presuppose that as an emergent property, resilience of a given food system-state is always subject to influence by resilience of systems that operate at larger or smaller scales. We have built our analysis around a resilience assessment in a rural community of Chiapas, but have sought to contribute to a much-needed debate on the global scale. In the study community, we evaluated aspects of economic, social and ecological resilience, based on interviews, surveys, and data sampling that were carried out over the course of two years of fieldwork in the Fraylesca region of Chiapas during 2010-12.

## 3. Resilience of the industrial food system

Allenby and Fink (2005) define resilience as the "capability of a system to maintain its functions and structure in the face of internal and external change and to degrade gracefully when it must." Accepting this definition, we should define the functions of the capitalist industrial food system and describe its structure, before looking for the critical thresholds that it may not cross without converting into a qualitatively different system. As with all activities driven by capital, the paramount function of the capitalist food system is to reproduce capital in greater quantities. This function has lead to a rationalization of economies surrounding food, based on the principle of maximizing the difference between costs and revenues in the application of capital to production, processing, distribution, and sales. In the productive sphere, rationalization means the maximization of commodity production. In order to maximize revenues, capitalist food systems have developed enormous structures for food processing in order to add to commodity value, as well as advertising to boost revenues. As capital has been slow to penetrate the actual farming process itself (Levins, 2007), due to its risky nature and bio-physical limitations, it has instead reduced the on-farm value added to commodities (i.e. cut into the farmer's income) by creating an industry of costly farm inputs, which are generally accepted as a part of the modern, monoculture form of growing food.

To think of the industrial agriculture model as a stable state on a food system continuum requires identifying its major components, defining the limits and time scale of the system, determining the values, peoples, and natural resources involved, analyzing the political economy and legal character of industrial agriculture, and recognizing the cross-scale interactions that all have an impact on system resilience (Kinzig et al. 2007). The essential components of a mature industrial agriculture model include the integration of food into free trade agreements, government support for agribusiness, market control over land and water resources, external input-intensive production models, monoculture and specialization, as well as an agricultural research establishment that focuses on developing profitable technologies. These conditions are largely met in Mexico as a whole, except for the millions of small-scale producers who continue to meet food needs at the local and national level using few external inputs and some form of communal land rights. The contradictory proliferation—and hybridization—of this model in socially and ecologically adverse circumstances deserves further attention.

The industrial food system represents the technological and organizational apex of a model first put into place in lands colonized by European powers. The monoculture is an invention of colonial economies, which treated dominated nations only as sources for cheap raw materials (including cheap food for a growing industrial working class). In Ireland, the monoculture potato production system was enforced by British colonial law that prevented the Irish from planting other crops. When a common pathogenic fungus destroyed the potato harvest, millions of Irish were killed by the ensuing famine. This is a classic example of the risk of the food system built on monoculture. Despite many such examples of spectacular failure, the industrial food system remains deeply committed to monoculture production systems around the world. The development of a global food system based on the increasing excursion of capital into farming has been a complex process, by which capital completely surrounded farming by taking over farm input and post-harvest economies while only slowly moving into the actual farming itself. Early stabs at industrial agriculture included the guano boat and phosphorus mining fertilizer industries in the late 1800s. In California, industrial agriculture and land takeovers were always linked (Walker, 2004), as wheat farming prospecting triggered a new "gold fever" and led to a bonanza period of often-falsified speculation on real estate.

A great new era began for industrial agriculture after the Second World War. Many countries were in ruins, and baby booms gave impetus to the US war materials industry to "convert swords to plowshares" and sell them to reconstruction programs. Factories that produced nitrogen-based explosives already had the entire infrastructure necessary to produce nitrogen fertilizers, tank assembly lines could easily be converted to create tractors, and many of the nastier chemicals used in war efforts were found to have satisfyingly lethal effects on insects and unwanted plants in agriculture. Even more importantly, the call for technical solutions to hunger was seen as an antidote to the more radical demands from structural change and wealth redistribution in order to combat poverty-caused hunger in the hopeful post-war and post-colonial world. Thus it was that the "green revolution," a broad program of agricultural research and technology development mostly focused on producing new high-yield varieties, was developed as production-focused solution to hunger in Asia, Africa, and Latin America.

Industrial agriculture is based on the intensive use of external inputs—such as improved seeds, fertilizers, pesticides, and irrigated water—to maximize yields. In the United States, this led to more overall production, causing the prices that farmers receive for their production to fall. As input costs rose and farm prices fell, small farms were squeezed by the low per-unit return on farming. The large farms that could produce at such a scale as to be profitable—despite the narrow margin between input costs and sales prices—started to swallow a much greater share of U.S. farm income. In 1969, the 1.2 percent of U.S. farms with the greatest annual income earned 16 percent of net farm income; by the end of the 1980s, they earned nearly 40 percent (Rosset, 1998). It is not necessarily the technologies of industrial agriculture that cause this concentration of agricultural income, but their application in societies where the advantage is already with wealthier growers and large agribusiness corporations. In such a social context, green revolution technologies tend to accelerate the concentration of food system resources, such as land and capital, in the hands of a few large players.

At a landscape level, the agribusiness model becomes best consolidated in conditions of potential ecological homogeneity and market control over economic resources (Perfecto et al. 2010). For this reason, its arrival to the Fraylesca region of Chiapas has been uneven—dominating the landscape in the large valleys, and barely felt in the most remote *ejidos* and family farms. The *ejido* system, as a form of collective property embedded in the national food system, has been a buffering element that kept local food systems viable in much of the Mexican countryside, especially in the southern states. Meanwhile, the large population of northern Mexico has created a more drastic contrast between delicate, rain-fed systems, and industrial farms built on fossil water.

This partially explains the highly disproportionate amount of private and public investment in agriculture in the northern states, while most support for farmers in southern states take the form of social welfare programs (Fox and Haight, 2010). The capitalist agribusiness model has been consolidated in northern Mexico in the generations since the end of the Second World War. In southern Mexico, it has arrived in waves—the most tidal of which was the destruction of state-owned grain warehouses and price regulations—which have yet to completely break the small farmer food system that retains a large geographic and nutritional importance, despite the dismantling of the economic structure that had been built around it since the Revolution.

Resilience in the industrial food system depends on two major objective factors: avoiding ecological destruction that would affect profit margins, and continued growth into new markets to prevent negative effects of overproduction. As global economies become more integrated than ever before and resource scarcity on a global level seems imminent, agribusiness corporations have moved into biotechnologies as a way to absorb huge sums of capital and—they hope—create vast new seed, energy, and pharmaceuticals markets. As a global system, agribusiness can easily leave behind devastated ecosystems and farm communities once degradation has reached the point that farming is no longer profitable. This has especially been the case in areas where long-term irrigation and synthetic fertilizer use have increased salt content of soils beyond thresholds of productivity, or on deforested land where original soil fertility is quickly exhausted to abysmal levels. While this kind of ecological and economic destruction is not threatening to the agribusiness model as a whole, it does threaten to create a social blowback, in the form of rural social movements and consumer groups, strong enough to threaten the future of the agribusiness model. In this sense, widespread social rejection of industrial agriculture is a subjective factor (i.e. dependent upon people's consciousness) that deeply influences the resilience of the system.

## 4. Resilience of the sovereign food system

Many efforts have been made to define food sovereignty (Patel, 2009). As an evolving concept, it has also been subject to growing social and academic interest, giving its full meaning an emergent quality in the historical conditions of 21$^{st}$ century social struggle (García-Linera, 2011). Nonetheless, we present a non-exhaustive list of components for economic, social and ecological resilience in sovereign food systems. While definitions are still being agreed upon, economic resilience among rural peoples may consist, at this particular historical moment and in many parts of the world, of several interacting components: 1) land access and unalienable rights to produce; 2) capacity to produce an abundance and variety of food necessary to meet most local food needs, essentially the potential to subsist with local production; 3) minimal dependency upon external inputs (e.g. hybrid seeds, pesticides) the availability and price of which are controlled by monopolies or foreign corporations; 4) maximum capacity to use local and renewable sources for energy and material needs (e.g. water, light, soil nutrition, farm labor); 5) use of diversified land-use and production systems, that may include extraction, agriculture, animal production, and small-scale processing in order to appropriate the value added by labor; 6) diverse income sources and form, which may include local products and off-farm employment, local and regional markets, direct contact with consumers, or in-kind payments; 7) real participation in the planning, design, and implementation of economic activities, through grassroots organizations or through governmental planning processes; and 8) the capacity to adapt and transform economic systems to better suit ecological and social necessities. Economic resilience allows systems of economic activities to withstand climatic shock, sudden scarcity or loss of markets, or long-term disturbance.

Social resilience, perhaps more difficult to define, includes at least the following components: 1) free and universal access to education and culture; 2) methods for sharing information and ideas vertically and horizontally in a way that combines theory and practice; 3) strong social organizations organized with democratic principles; 4) access to a common identity that admits and is strengthened by diversity; 5) access to universal and affordable health care; and 6) respect for social and economic human rights, such as the human right to food. This is clearly not a static situation, but rather a dynamic learning and adaptation process subject to conflict and contestation, as well as consensus. Ecological resilience could consist of: 1) ecosystems based on material cycles (e.g. hydrological, carbon, nitrogen), energy flow through trophic webs, and ecological interactions between biotic agents (e.g. competition, predation, mutualism, commensalism, parasitism); 2) productive patterns that maintain the possibility for indefinite temporal continuity without degradation to material cycles; 3) diversity of function in the ecosystem, with the greatest possible number of niches filled; and 4) redundancy of function, so that the potential loss of some species can be compensated by the activity of others.

In order to think of food sovereignty as a stable state or domain of attraction, it becomes necessary to define the "pull" that is capable of directing a food system transition, once the thresholds of the industrial food system have been reached. The direction and strength of this force of attraction almost certainly depends on which thresholds have been reached in the industrial food system-state. Sometimes in order to better understand the resilience pull effect, we can ask ourselves, in any given context, what the easiest option is. In the contradictory dominant order of a globalized, capitalist food system, where are there activities that, when certain thresholds have been passed, become easier to do by conforming to the logic of food sovereignty rather than the logic of capital accumulation? Clearly, the access to conventional farm inputs is a defining pull toward the capital-influenced agricultural model. Thus maybe one starting point for a regime shift could be the end of access to conventional, yield-intensifying chemicals and seeds. This was indeed the case in Cuba, the world's greatest example yet of a national-level transition from an industrial agriculture model to an organic, diversified, low-external input agricultural model. When conventional inputs, petroleum, and imported food all become unavailable due to the fall of the Soviet Union and the US trade embargo, Cuba's small farmers, scientific community, and government teamed up to direct a national inward-looking agricultural effort, based on organic urban gardens, agroecological small farms, and the breaking-up of unproductive state farms into cooperatives more directly controlled by workers (Rosset and Benjamin, 1994). In this case, the perturbation was an acute food crisis; the response was a rapid, dramatic regime shift toward the food sovereignty framework.

In other cases, the defining pull that defines food state transitions could be the social demand for land, as was the case in those that accompanied the Mexican Revolution. There is also the eternal drive for greater social justice and equality, which has been a major component of food sovereignty-themed social movements in countries such as the United States and Brazil. In the case study below, the driving pull toward a food sovereignty state of the food system is the concern for human health.

## 5. The focal system

By focusing on one maize-growing community in rural Chiapas, we set out to understand the resilience of a maize production system to external disturbances and internal contradictions that jeopardize its natural resource base and the health of its inhabitants. That is to say, we are interested in the factors of social-ecological resilience in a small farmer agroecosystem at the community/landscape level over the next couple decades. In Mexico, land reform resulted in the creation of *ejidos*, or agrarian communities of small producers with internal political structures. The *ejido* system is itself a complex adaptive system that has survived decades of neoliberal food and land policy at the national level. Within one *ejido*, our study focuses especially on the food production, distribution, and consumption surrounding what is known as the *milpa* system, or the fields where maize is grown, in 25 hectares within the limits of the *ejido*. The overall shift toward the agribusiness state in Mexican maize farming is an uneven, long-term trend which takes place over the course of decades and has a series of social and ecological feedbacks.

The critical components of the current system include farmer families, land access, synthetic fertilizers, hybrid seeds, and chemical herbicides, as well as maize purchasers. Critical components of the restored agroecosystem will include local knowledge and farmer identity, community interest in health and nutrition, soil fertility, functional agrobiodiversity, farmer-to-farmer knowledge exchanges, strong local organizations, traditional seed varieties, organic fertilizers, and crop rotation (Milestad et al. 2010). Important natural resources in the focal system include biodiversity, clean water, fertile soil, forest carbon, and knowledge in the form of traditional maize varieties. Key people include the producer families, including elders, women, men, and children, while critical values include the relative interest in short-term income versus long-term economic sustainability, the capacity to coalesce around the concept of health, and the impacts of belonging to the small farmer social class (Guevara-Hernández et al. 2011b).

The *ejido* system is a form of local governance, not only for land issues but also for other social issues such as health. Property rights reflect a mix of collective and private land-holdings, with complex informal arrangements used for producing food on the land that is closest to the community, regardless of who is the legal owner. There is a definite lack of strong rural organizations in the region, leading the *ejido* structure, the elementary school, and the local church to hold a monopoly over collective action in the community. Maize farming communities in the region, as in most of Mexico, are highly dependent on government anti-poverty programs, as these have come to replace most productive subsidies and credit mechanisms. Obviously, multinational farm input corporations are untouched by democratic institutions that might be used to control the use of toxic chemicals in the community or promote local seeds (Bakan, 2004). Indeed, scale factors deeply influence the capacity to characterize the resilience of the focal system, because its resilience is intertwined with that of the agribusiness model at the international level, as shown below in table 1.

In order to assess social-ecological resilience, at the focal scale of one maize-growing community in Chiapas during the recent past and near future (10-30 years), we will look for the cross-scale interactions between components in table 1 and describe their feedback mechanisms (Buchmann, 2010). In the next section, we give a context for understanding the local food system in the study community.

| *Scales of variables* | *Food system components* |
|---|---|
| ***Spatial Scales*** | |
| Microbiological | soil ecology, nutrition assimilation, chemical exposure to organisms |
| Field | net primary productivity, cost of production, maize yield, planned agrobiodiversity, diversity of associated plant and insect species, soil health, use of trees, use of organic fertilizers, pest and plant disease |
| **Community/landscape** | **attitudes, knowledge, organization, experimentation, crop diversity, out-migration, conflict, human health, nutrition, economic necessity, access to social assets, access to land, landscape matrix quality** |
| Subregional | health indicators, land use, public policies, level of influence of agribusiness, growing seasons, farm prices, social equality, farmer organizations, political economy and actors, capacity for self-reliance in key crops |
| National | food policy, environmental policy, trade policy, agrarian policy, education policy, health care policy, popular participation in democracy, adaptive governance, level of influence of transnational corporations |
| Global | climate change, global social movements, capitalism |
| ***Temporal Scales*** | |
| Hourly, Daily or Weekly | food security, physical activity, household labors, planting dates, weed control, soil biological processes |
| Seasonal | production cycles, climate factors, weed and insect communities, off-farm income, farm prices, training programs, implementation of government supports |
| Annual | farm productivity, learning-by-experimentation, community demographics, government policies, farm prices |
| **Decade-level** | **soil erosion and compaction, landscape mosaic quality, land use changes, trade policy, market influences, climate change, crop suitability** |
| Longer-term | land use, population factors, national sovereignty, world economic system |

**Table 1.** Spatial and temporal scales in food systems. Focal scale is in bold.

## 6. Regional characteristics and historical context of the study community

The Fraylesca region is a hot and dry tropical zone that comprises the Central Valleys of Chiapas. Its major city, Villaflores, is located about two hours' drive south of the state capitol of Tuxtla Gutierrez, but the region continues another 100 km to the southeast. The Fraylesca traces its name back to the monks who habited the zone during the early colonial period. It is one of the regions of Chiapas with the least presence of indigenous language-speaking groups, probably due to the productivity of its lands and resulting displacement of the indigenous population during the colonial period. During the 1960s and 1970s, the Fraylesca region was known as the maize equivalent of the breadbasket (*granero*) for southern Mexico, where flat, alluvial valley floors gave typical maize harvests of 5-8 metric tons per hectare. Green Revolution technology, introduced through concentrated efforts to modernize maize farming systems in the flatlands, trickled upstream into the hills as population growth and limited land access pushed families upwards. By the 1990s, the vast majority of traditional maize varieties had been lost in the region, due to adoption of hybrid varieties in government seed programs and corporate advertising. The traditional shifting *milpa* agriculture system was generally replaced by a system of permanent fields in which maize is planted in monoculture during the first rainy season from June to July. Chemical laden maize fields came to dominate the landscape, while posters advertising agricultural chemicals and hybrid seeds are pinned to trees along the highways.

Recent decades have produced change in the Fraylesca region. Increased costs of maize farm inputs, together with soil degradation and low farm prices, appears to be putting the commercial maize farming system in economic jeopardy. Cattle-ranching has been increasingly embraced by hillside farmers, who graze beef cattle on maize stalks during the dry season and set them into the forest during the rainy season. More commercial lowland cattle operations buy the chicken manure from massive chicken farms in the region and feed it to their cattle, in order to produce greater volumes of milk and beef. This practice is generally disliked by the population, but that has not prevented it from becoming the conventional practice adopted by ranchers and dairy farmers. Intertwined with the growth of cattle-raising and the uncertainty of maize cultivation, the changing climate has added to the insecurity of social-ecological systems in the Fraylesca region. Growing seasons have shifted as annual precipitation has begun to concentrate in the second rainy season of the year from September to November, increasing the risk of cob-rot fungal disease. Rainfall has become scarcer during the long dry season from December to May, leading farmers to concentrate their cropping activities between the months of June and October.

Land tenure in the Fraylesca region is subject to similar social tensions to those that have characterized Chiapas as a whole during the last 50 years. The agrarian reform of the Mexican Revolution was slow in arriving to Chiapas, and the *finca* system of large landlord estates remained intact into the 1920s. The first *ejidos*, or agricultural communities created and protected by Mexico's agrarian reform laws, were created in the region as a result of social struggle in the 1920s in valley floors, and currently resemble small towns of paved streets, parks, and residential neighborhoods. As population pressure increased, peasant families have challenged landlord estates across the landscape, building makeshift communities in remote hills and asking for government recognition. Until the constitutional counter-reforms of 1992, Mexican land policy included a legal process for recognizing land claims through the Secretariat of Agrarian Reform (SRA) and reimbursing landowners for the forfeiture of unused land to new agrarian communities, which in turn could become *ejidos*. These second- and third-generation settlements differ in many respects from the older *ejidos*, in that they have much less access to health and education services, markets, transportation, and government supports. In newer *ejidos*, maize farming and cattle grazing take place on slopes that are much more vulnerable to erosion than the alluvial flatlands of the valley floors. As the Zapatista rebellion and federal military occupation of much of the Los Altos region took place in 1994-95, indigenous communities displaced by the violence began to look for land far into the hills of the Fraylesca region. These communities, fleeing from bloodshed, occupied land belonging to large and small landholders alike and sought federal recognition. While many such communities have obtained a certain level of land security by gaining *ejido* status, others remain in situations of precarious land tenure despite more than a decade of waiting for governmental recognition, even while cultivating the landscape and constructing homes.

## 7. Characterizing small farmer maize production in 24 de Febrero

The *ejido* of 24 de Febrero is about 45 minutes' drive south of Villaflores, in the municipality of Villa Corzo. The community is situated at 16°06′30′′ north and 93°22′33′′ west, at an altitude of 900 meters above sea level (Figure 2). The climate is considered subhumid tropics, with an annual precipitation of 1,248mm, concentrated in five months from June to October, and a mean temperature of 24° Celsius. Of the 1,240 hectares that belong to the *ejido*, 650 hectares are considered forestland and areas of important habitat for rare species of mammals, birds, reptiles, and amphibians. No more than 40 hectares are dedicated to maize cultivation in any given year, and often on fields with between 5 and 20 years of continuous maize monoculture production. Meanwhile, the area dedicated to cattle production shifts across the landscape, from pastures to former maize fields to forestland.

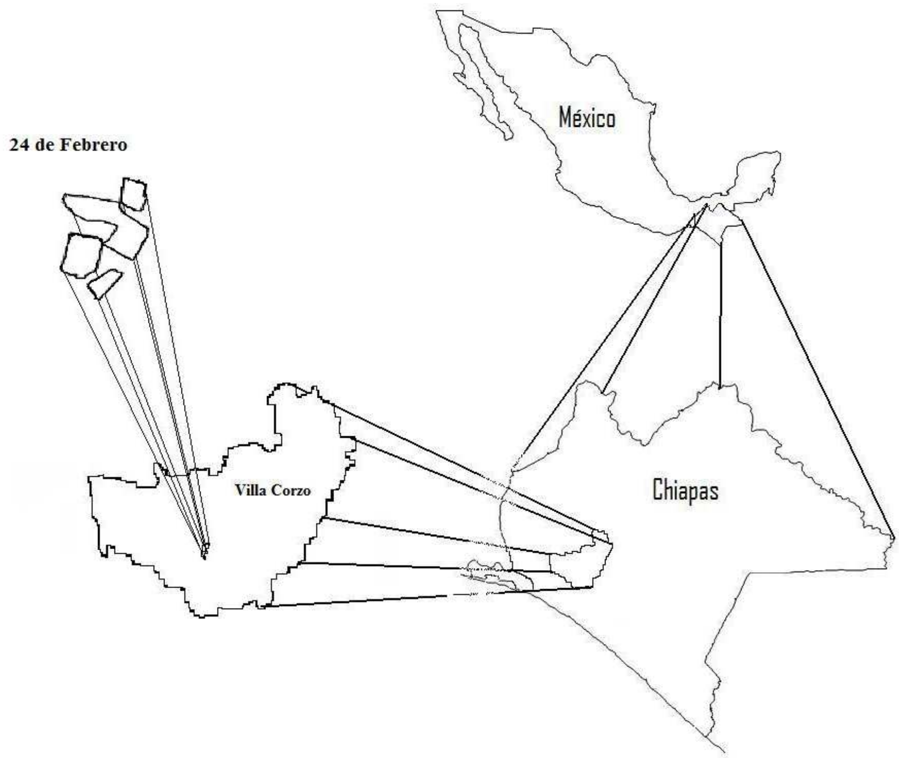


**Figure 2.** Geographic location of the *ejido* 24 de Febrero, in Villa Corzo municipality, state of Chiapas. Source: Rural Development Studies Network (2011).

The community of 24 de Febrero is primarily made up of one extended family of blood relatives and in-laws. None of the residents of the community speak an indigenous language. In contrast to many *ejidos*, the founders of the settlement were small farmers in nearby lands between the current community and the valley floor. In the mid 1980s, a group of peasants from a different part of the Fraylesca region organized with a lawyer to occupy lands belonging to one of these small farmers. In response, a large part of the extended family organized to create an *ejido* on the contested lands, and thus avoided a land conflict between peasant groups. So it was that the *ejido* 24 de Febrero was founded in 1986 with 5 homes. In subsequent years, the settlement has grown to include over 50 homes, with most new construction by sons and daughters of the community's founders. In the entire community, there are only 38 maize farmers, due to cost/benefit pressures that have taken out of production several former fields that are now considered to be too far to walk from the community.

*Transition from the original subsistence system*

OG plus no fires, OG plus fertilizante, etc.

*Risks in the degraded state: soil erosion and cob-rot disease*

We need to evaluate soil erosion in the 18 fields, as well as damage due to the cob-rot disease.

Farmers in 24 de Febrero plant both purchased maize seed and several native or mixed varieties that have been used by local farmers for generations. Planting usually takes place in the months of June and July, when torrential rains soften land. Maize fields are typically about 15 to 45 minutes' walk from the population center of the community, and are generally on sloped hillsides that are deeply eroded. Some farmers mix their seeds with chemical pesticides in order to limit damage from ants, while others use local herbs such as *epozote* to the same effect.  Planting is carried out using hollow gourds to contain seeds, and a wooden stick with a metal tip to open up small holes in the untilled soil. Two or three seeds are tossed into each hole, which are made every 40 cm in rows of 80 cm width. Some farmers still follow the traditional practice of mixing squash seeds in with their maize seeds, in order to plant squash every 3m or so throughout the field.

Generally farmers clear fields for planting by using a systemic herbicide such as glyphosate, applied soon after the first rains in May. A few farmers still burn fields before planting maize, although only in areas that haven't been planted with maize in several years. Around 4 days after planting, most farmers apply a contact herbicide, such as 2,4D amina or paraquat. At 15-20 days, farmers apply a dose of nitrogen or phosphate fertilizer. Another herbicide treatment is carried out at 40 days with 2,4D amina and paraquat. At 45-50 days, a second fertilization is carried out. Maize plants are bent over below the ears only in fields where beans are planted in between rows, during the months of September and October. Sweet maize is harvested in September and October for family consumption, while the vast majority of maize ears are left to dry in the fields and harvested from December to March (table 2).

| Jan | Feb | Mar | Apr | May | June | July | Aug | Sep | Oct | Nov | Dec |
|---|---|---|---|---|---|---|---|---|---|---|---|
| Maize harvest | | Home gardens, sugar cane and off-farm activities | | | • Plant maize<br>• Plant squash | | 40 days of heat without rain | • Plant beans and harvest sweet maize | | •Bean and maize harvest begins | |
| Dry season | | | | | First rainy season | | | Second rainy season | | Dry season | |

**Table 2.** A seasonal calendar for cropping activities in 24 de Febrero.

During harvest, farmers remove only the corn ear, and leave all crop residues in the field. Soon afterwards, cattle are generally moved into harvested fields to graze upon the maize stalks. Cattle manure and pulverized maize stalks encompass the major sources of soil organic matter. Crop rotation is a very rare practice in the community, as maize is the only commercial crop and additional food crops such as sugar cane, banana, chili peppers and yucca are grown in small, separate batches. The practice of leaving fields in fallow, or several years of woody bush and chaparral tree regrowth in between cycles of maize production, was largely abandoned with the adoption of synthetic fertilizers by the community. Crop association, however, remains as a traditional practice in several fields, where farmers plant squash seeds along with their maize and beans in the latter rainy season.

## 7.1. Conventional and alternative practices

Figure 2 shows the ecological quality of several chemical practices in the community. A value scale from 0 to 3 was applied to four indicators of chemical usage, following a method for quantifying ecological quality of management practices (McCune et al. 2011). A value of 0 denotes practices with no benefit and with harmful impacts to ecological processes, 1 represents practices with no benefit but with a minimum of harmful effects, 2 denotes practices with minimal or insufficient benefits to ecological processes, and 3 represents practices with broad ecosystem benefits and that are applied with ecological criteria.

For example, in the case of chemical inputs as shown in Figure 2, the value attributed to each product is essentially the inverse of usage intensification; e.g. the higher value for 2,4D amina shows that this product is less widely used than paraquat. The indicator practices were chosen to be sensitive to changes from the conventional practices found in the community, in order to indicate where processes of innovation may be entering into maize farming. Combinations of organic with conventional fertilization practices remain very rare in the community, as do responses that indicate that farmers believe that it is possible to produce without conventional inputs. Incipient processes of innovation were found in the use of composts for fertilization, and in substitution for paraquat, a contact herbicide that is also a respiratory toxin. In 2011, four farmers were experimenting with liquid mixes made from the leaves of two common trees (*Ficus* spp. and *Byrsonima crassifolia*), along with fine salt and one-tenth the normal dosage of paraquat. Results were encouraging, although the next steps for expanding the usage of these homemade liquids are unclear. Despite the farmer experimentation taking place, chemical fertilizers and paraquat-based herbicides were most intensively used of the four indicators of agrochemical use among the 18 farmers surveyed.

The information in Figure 3 can be useful for determining the kinds of dependence produced within small farmer communities in Chiapas. The extreme dependence on synthetic fertilizers is an indicator of the level of soil erosion present in agricultural fields. Aside from highly unusual, small-scale efforts at growing organic maize for specialty markets or home use, the only maize-growing systems in Chiapas without this dependency

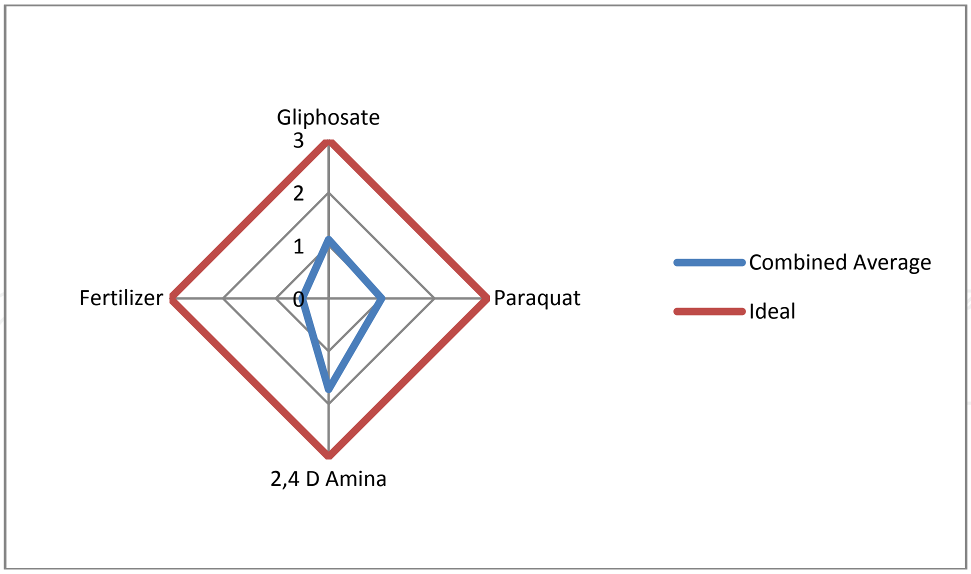


**Figure 3.** Ecological quality of chemical input use for maize production in the ejido 24 de Febrero, using an indicator system on a scale of 0 to 3. The value of zero represents maximum chemical application, while the value of three represents no usage.

on chemical fertilizers are the traditional shifting agriculture systems in which the forest re-growth of long-fallowed fields is cut and burned, and seeds planted into the rich layer of ash.

It is useful to identify the constraints and feedbacks of soil fertility management in Chiapas maize production. Fertilizers represent the greatest cost of maize farmers, with typical costs in 24 de Febrero reaching well over $1,000 US per hectare. Yet substitution of synthetic fertilizers with organic soil amendments is difficult, because hillside soils are so badly eroded that existing soil has almost no nutritional content, and up to 40 tons of organic matter per hectare would need to be applied in order to satisfy nutritional requirements of maize. The production and transportation of this volume of organic fertilizers would require large inputs of labor, difficult for farmers to provide as livelihood diversification strategies have left less time for maize-production activities than before. Thus the availability of time and labor (or cash in the case of purchased organic fertilizers) is a limiting factor for the efforts to break the dependency on synthetic fertilizers. The sloped maize fields represent an additional restraint, in that erosion is likely to undo most soil amendment applications until a massive labor effort goes into erosion-reduction practices, such as stone or stick terracing.

Feedbacks between management and ecological factors also complicate efforts to reduce fertilizer dependency. For example, populations of soil organisms that could improve soil structure and nutrition over time are likely to be negatively affected by the application of chemical fertilizers. In addition, cattle grazing in maize fields during the dry season can exacerbate erosion and also cause soil compaction. Compared to other crops, maize is hardy to degraded soil structure as long as sufficient nutrients are present. Indeed, farmers feel that its capacity to adjust to poor soils is an aspect of maize's centrality as "the" subsistence crop. Thus the economic need to produce every year is combined with the fact that maize is the only crop that can be produced under such marginal conditions, to create a system of monoculture maize production year after year in the same fields. Legal prohibitions on burning are meant to limit landscape degradation, but they also effectively end shifting agriculture, since fire is the typical way to open sloped fields to agriculture. Without shifting fields or rotations, soil degradation is accelerated to alarming levels.

The use of herbicide cocktails is a characteristic of maize farming in the Fraylesca region. The major restraints on reducing herbicide dependence are related to the labor opportunity cost, as manual weed removal takes a great deal of time that can be otherwise used productively by households. New ideas such as the organic weed retardant may represent the most promising directions for reducing herbicide dependence. Management feedbacks also exist with regard to herbicide use. After herbicide disturbance to fields, pioneer species such as aggressive weeds are the first plants to take advantage of nutrients and light in the newly opened spaces. The practice of herbicide application tends to increase the relative abundance of plants species that establish competitive relationships with maize crops. Fields with frequent use of herbicides tend to have major problems with a few key weeds, whereas fields without herbicide use have a greater diversity of associated plant diversity, including beneficial and non-competitive species.

A final interesting aspect of farmers' chemical use is the high dependence on herbicides and very infrequent of insecticides in the maize cropping system. In general, insect pests are not considered to be more than a nuisance, while farmers identify over 10 beneficial insects, mostly insect predators and parasitoid wasps (see below).

Over the course of two or three years, the community has progressively given more importance to ecological considerations, partly as a result of a training course in environmental education offered by the National Forestry Commission and carried out in the *ejido* by a local NGO in 2010. As a result of this course and follow-up activities by a participatory research team from the Autonomous University of Chiapas, several farmers have engaged in communication and experimentation with the purpose of substituting organic and traditional inputs for chemical inputs in agricultural activities. These and other alternative activities, such as a promotion of herbal medicine, are being adopted explicitly out of concerns for human health that emerged in monthly *ejido* assemblies, where the residents attributed poor health to chemical usage and the diminishing quality of diets. A first practice of seed saving using such traditional materials as ash, lime, and several kinds of herbs was carried out with the participation of 18 farmers. Of these, five attempted to grow fields of organic maize in 2011 using compost and organic fumigants. Figure 4 shows indicators for the appropriation of agroecological practices by the same 18 maize producers in the *ejido*. A similar value scale as with chemical use was applied to four indicators of alternative productive activities: nutrient cycling, crop rotation, crop association (intercropping), and seed management.

Our results showed a much greater appropriation of nutrient recycling practices than alternative seed management and crop association activities, basically due to the local customs of leaving crop residues in the field, moving cattle into former crop areas to eat the maize stalks, and the total absence of plowing. Crop rotation was shown to be a major

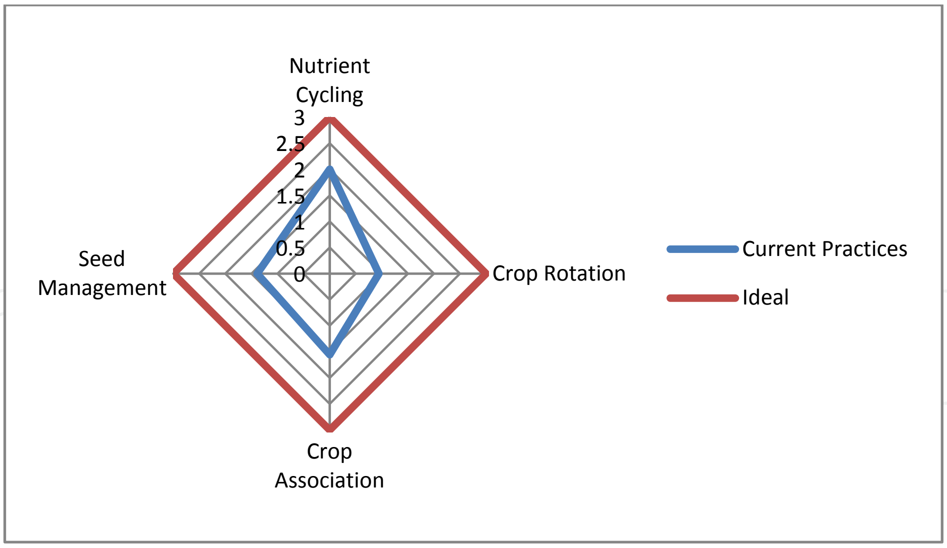


**Figure 4.** Ecological quality of alternative practices for maize production in the ejido 24 de Febrero, using an indicator system on a scale of 0 to 3. The value of zero represents total absence of alternative practices, while the value of three represents widespread use of ecological practices for reasons that farmers understand.

problem in the community, as annual crops of maize dominate the agricultural landscape during the single growing season. Maize is the preferred crop due to its importance as a food crop, its durability as a commercial crop, and its response to fertilizers even in highly eroded soils, providing a lightly positive cost-benefit balance to farmers for years even as soil quality declines. Cultural preference for maize makes diversification of the productive landscape a complex and sensitive process.

## 7.2. Biological interactions in maize production systems in 24 de Febrero

Weed and insect communities within the maize fields show that even under existing conditions and technological patterns, the small farmer landscape is capable of supporting a rich diversity of species and functional groups. This is an especially important finding, given that agriculture and biodiversity conservation are often considered in neoliberal theory to be mutually exclusive, even competitive uses for land in the tropics (Grau and Aide, 2008). The idea of contradictory agricultural and conservation goals, and the necessary segregation of the two, has led neoliberal resource economists to support wilderness reserves in some parts of the rural tropical landscape and industrial agriculture in the rest (Aide and Grau, 2004). The problem, as pointed out by rural organizations, is that small farmers are essentially excluded from both parts of the landscape, and conservation policy then becomes a tool for the dispossession of family farmers and rural communities. In addition to small farmer objections, the neoliberal model of biodiversity conservation has been challenged on ecological grounds, as recent decades of theory on metapopulations has shown the importance of migration between habitat patches for species survival. According to this conservation paradigm, also known as the convergent model of mixed land-use (Miki et al. date unknown), agricultural systems that retain elements of the original ecosystem can promote successful migration between patches of wilderness. This may make the ecological quality of agroecosystems even more important than the conservation of habitat patches to biodiversity conservation in the tropics.

In 18 fields of 24 de Febrero, weeds and crops were measured monthly for the percentage of area they covered within three 50cm x 50cm quadrants placed using a random block design in each field, for a total of 54 quadrants, during the six-month maize growing season. In the total studied area of 13.5 square meters, over 30 species of weeds were found, reflecting high overall richness despite the use of herbicides. Tree cover and type varied among fields, but crucially, trees were present in all fields. The uses for weeds and trees were various; eight weeds were considered to be edible, and 11 were identified as medicinal plants. Among trees, several were nitrogen-fixing legumes and others were fruit-bearing, with the remainder having social use as building material, medicine, or firewood.

We identified 29 families of insect herbivores, seven families of secondary consumers or predators, 12 families of parasitoids, and two families of pollinators in five samplings across the eighteen study fields during the growing season of 2011. The insect community within maize fields reflects a high level of biodiversity and is likely to have the net result of stabilizing yields, creating an "ecological homeostasis" through complex networks of trophic, life-cycle, and density-dependent interactions (Vandermeer et al. 2010). The critical interactions within such an autonomous agroecological service such as pest control may be highly complex and occur on various spatial and temporal scales.

In 24 de Febrero, maize fields also bear beans, squash, tomato, edible herbs, several medicines, and several use categories of trees. This multi-use aspect of agricultural fields may lend itself to system resilience, since any detrimental impact on maize production is partially offset by the other functions of the same land. Land-use diversity is an element of system resilience that is pronouncedly strong in small farmer settings (Altieri, 2010). While the use of the farm landscape in 24 de Febrero retains an important level of diversity, it is also useful to ask why it doesn't have even more, especially given the supposition that small farmers maintain diverse productive systems. To understand the drivers of land-use change and agricultural intensification, it becomes necessary to examine the social and economic vulnerability of small farmers in Chiapas.

### 7.3. Characterizing social resilience

Livelihood is an important concept for understanding risks in social-ecological systems. Both vulnerability and livelihood trace their conceptual roots in the search by Sen for adequate measures of well-being (1993). Livelihood has to do with the relationship between households and the conditions of their production and reproduction as an economic unit, including housing, employment, income, access to basic necessities and to consumer goods, transportation, health, and education. It is generally used to define baseline measures of human well-being, and as such applied to small scale rural producers and the rural or urban classes without property. While livelihood studies generally examine immediate aspects of economic life at a household level, vulnerability studies tend to focus on structural factors, such as legal, political, cultural, ecological or economic factors that threaten livelihoods.

In order to make an initial characterization of livelihood resilience factors in the community of 24 de Febrero, an indicator system was created to include among its variables: food access, health care access, access to credit, access to public programs, access to markets, access to alternative technologies, and access to education (Figure 5). These access indicators are significant to everyday life under normal circumstances, but they are also indicative of social risks that could become urgent under changing conditions.

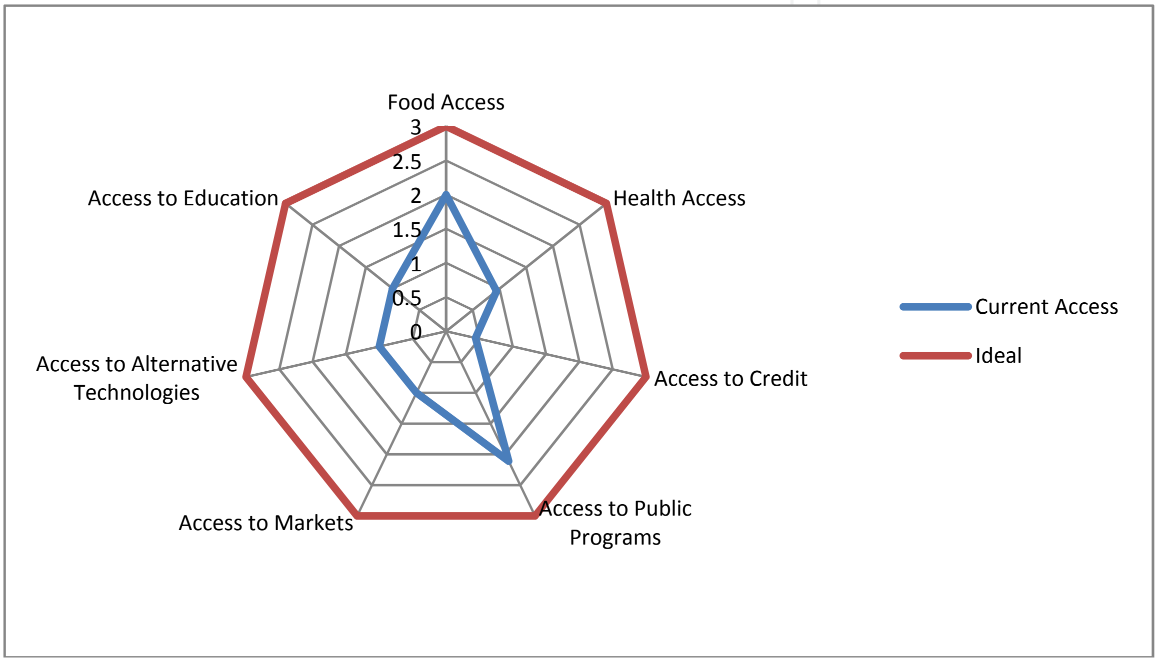


**Figure 5.** Factors of livelihood resilience in the ejido of 24 de Febrero, using an indicator system on a scale of 0 to 3. The value of zero represents abandoned or systematically denied access rights, while the value of three represents free and universal access as well as participation within planning or implementation processes.

Results confirm the existence of several types of social vulnerability in the community. Indicator values for access to food and public programs were substantially greater than those for other variables. Values were notably low for access to education and access to credit, two indicators related to opportunity. With regard to education, the attained value of one means that the average response to interview questions was that beyond elementary school, monetary costs associated with education made it inaccessible. The very little access to credit for farmers in the maize growing regions of Chiapas is a matter of considerable importance for the community of 24 de Febrero, and contributes to migration by young people to the United States in pursuit of sufficient cash to construct homes or purchase fertilizers. At the same time, the conservation of certain traditional practices is often attributed to the lack of farm credits, which would enable farmers to pursue a more technified production strategy.

## 8. Food sovereignty and the nation-state

While we have characterized many aspects of the maize production system in 24 de Febrero, the question remains: where is the community located on a gradient between agribusiness and the food sovereignty model? Clearly, the food system of the community is somewhere in between the two states that we have described. Its combinations of traditional and conventional technologies, cash- and subsistence-oriented agriculture, monoculture and multi-use systems, indeed, environmental stewardship and degradation, give the local food system a character highly compatible with the sovereignty system state. However, the community is within a nation that has been subjected to the full formula of capitalist agribusiness.

Here we come to a fundamental issue of scale: the local food system in 24 de Febrero can only be understood in its larger context, as part of Mexico's food system. On one hand, it is an adaptation on the traditional *milpa* system of maize production on collectively held lands that has characterized Mexican food systems for millennia. On the other hand, it is the result of the extension of capital logic and conventional technologies to far corners of the Mexican countryside, bringing junk food and chemical input dependencies to the rural household. The ambiguity is a signal of the importance of scale, and it may well be possible that systems within the gravitational pull of one steady state could also exist within another. For example, the Procede land certification policy enacted during the 1990s was thought to be the end of collective landholding in Mexico, as it partitioned private titles for *ejido* lands and legalized land sales (De Ita, 2000). However, the internal resilience of the *ejido* system, based on social and political feedback mechanisms, was strong enough that certification did not have the same effect that it has in other parts of the world, such as Africa and the Middle East.

At a larger historical scale, collective resource-use regimes such as the *ejido* system may be momentarily compatible with both capital-driven and socially-planned economies. In this sense, a valid comparison can be made between *ejidos* of Mexico and agricultural production cooperatives in Cuba, both of which are based on profound land reform and collective agrarian property governed by local assembly. Such institutions can exist within countries dominated by the industrial food model, but the dynamic of the overall food system will determine how long they last and how they change. The *ejido* was created as a compromise between the radicalized peasantry of the Mexican Revolution and conservative groups of power that were interested in limiting resource redistribution. By giving *ejidos* to peasants, militant rural organizations could be demobilized and wages could be kept low during industrialization, since industrial workers' wages were supplemented by their access to productive land. Essentially, the *ejido* was a major tool for the consolidation of a new bourgeois regime after the Mexican Revolution. It was the eventual reorientation of the national economy toward global capital and away from nation-building in the late 1970s that brought the *ejido* system into conflict with the emerging neoliberal resource management regime. The temporary compatibility of agrarian systems that have a food sovereignty character, such as the Mexican *ejido*, within industrial food systems that are in the process of consolidation, is a matter of scale and historical contingency. Components embedded in one kind of food system can reflect a distinct qualitative character, as long as they are so limited in scale and impact as not to push the larger system to a threshold.

The dependence of the maize production system in 24 de Febrero on foreign multinational corporations and the chemicals they sell is a sign of its integration into the international capitalist development model that dominates Mexico from outside. As maize sellers, they are limited to the white maize varieties sought by middlemen buyers en route to large-scale tortilla production (mixed first with maize from the state of Sinaloa or, increasingly, the United States) or exportation to Guatamala. Surrounded by an agricultural landscape of maize fields with hybrid seeds, the integrity of their traditional varieties is at risk of contamination. It would seem that in neoliberal Mexico, the community is within the outer reach of the industrial food model and as such, subject to its contradictions. Nonetheless, on a household level, there remains a level of resistance to the industrial food system, which takes the form of self-sufficiency in basic grains, conservation of landrace maize and bean varieties, use of home gardens, traditional labor-sharing arrangements and artisan food processing. These are all components of the local food system consistent with a food sovereignty framework, but they are gradually disappearing from the landscape. What is the role of the Mexican State in this transformation?

### 8.1. Devolutionary governance

Since the Mexican Revolution of 1910, national policy toward agriculture has reflected a struggle between peasant groups that have fought for land access and favorable policies toward small farmers, and a combination of business and political elite from within and outside of Mexico that have sought to develop a capitalist, export agriculture model. Since the dawn of the twentieth century, capital investments began creating two basic tracks for Mexican agriculture: the capital-intensive irrigated, specialized farms in Central and Northern valleys and plains, and subsistence agriculture in most other non-urban land in Mexico. This split in land use reinforced the nation's conception of monoculture as "modern," and diversified, low-input farming as "backward."

The agricultural research and technology program that came to be known as the Green Revolution was largely a US Cold War-era effort to resolve issues of hunger and poverty in Mexico with technical solutions, rather than new social and economic policy (Perfecto et al. 2010). The proliferation of new, "modern" seed varieties, as well as irrigation infrastructure, synthetic fertilizers and pesticides during the 1960s, 1970s, and 1980s, was a highly uneven process that reflected the compromise between corporatist governmental policy beneficial to large agricultural interests, and the commitment to

Since the 1980s, Mexico's government has opted for a free trade strategy in all productive spheres, as a result of changes in the economic ideology of the ruling party, as well as external pressure from international lenders and the United States. For Mexican industry, this meant the final and unequivocal abandonment of the import-substitution industrialization strategy. In commerce, it eventually led to the signing of the North

American Free Trade Agreement in 1993, which opened up Mexican markets to a flood of cheap products from the United States. In agriculture, the adoption of the free trade model meant a shift in strategy from the goal of self-sufficiency that had characterized agricultural and land policy since the revolution. Guaranteed farm prices for basic grains such as maize disappeared, as the state reduced its presence in the countryside and international private actors stepped into the void. Cheap grain from subsidized farmers in the United States began to flood Mexican markets, adding to the economic insecurity of millions of Mexican maize farmers. Meanwhile, the price of tortilla, the basic and essential form of maize in the Mexican diet, has more than tripled for consumers since NAFTA was signed, as a result of concentration of the maize storage and processing sectors by several transnational corporations.

One of the most controversial issues in contemporary Mexico is the entrance of genetically modified maize into the country, almost universally from the United States, as seed, feed, or food. In 2001, Mexican and U.S. researchers accidently found traces of genetically modified maize in landrace varieties of rural Oaxaca (Quist and Chapela, 2001, Nature 414), and subsequent studies have confirmed the contamination of maize landraces by modified genes across Mexico. Given the extraordinary cultural and alimentary importance of maize in Mexico, the loss of traditional agrobiodiversity in this crop represents a loss of national patrimony and sovereignty. In 2007, President Felipe Calderon created by decree a federal program to support *in situ* conservation of landrace maize varieties by farmers. However, the Secretary for Agriculture, Livestock, Fish and Food (SAGARPA for its initials in Spanish) was cold to the proposal, as it went against the productivity focus of its programs. Thus it fell to the Secretary for Natural Resources and the Environment (SEMARNAT) to take on the maize biodiversity program. SEMARNAT, in turn, sent the new law to its National Commission for Natural Protected Areas (CONANP), which began to apply the program, its implementation having now been reduced to agricultural areas within nature reserves.

CONANP's Program for *in situ* Conservation of Landrace Maize, or PROMAC (*Programa de Maíz Criollo*) as it is more commonly known, is still a new fish in a very complex pond of federal and state programs that combine agriculture and natural resource conservation. It pays about $100 US per year to farmers who have been growing landrace maize varieties in nature reserves to continue growing them, and advocates the conservation of the traditional *milpa* productive system (maize in association with squash, beans, and other edible plants). PROMAC funds are used based on the discretion of each nature reserve, and can be used to hold seed exchange fairs, conduct capacity-building trainings for farmers, build seed banks and even create maize-based cultural centers. While this program clearly has the potential to strengthen the peasant maize production system, its capacity to help small farmers and protect landrace maize varieties depends on how it is implemented in each nature reserve. In interviews, many nature reserve officials compare PROMAC to PROCAMPO: a program created during the administration of Carlos Salinas (1988-1994) to buffer his free trade economic shocks and which pays annual subsidies to all citizens who show documents proving that they grow crops or raise livestock. Despite its populist appeal, PROCAMPO is a notoriously inefficient program, as its implementation provides ample opportunity for fraudulent payment claims and requires no participation in training programs or production plans. Many Mexican politicians at the national level oppose support of any kind for maize production, because they see it as a marginal subsistence activity that is outside of the free market agricultural strategy of specialized crop exports and basic grains imports. Thus from its origins, PROMAC has been born into a hostile and disjointed institutional atmosphere, in which some nature reserves have ignored the program while others have encouraged farmers to enter into it.

While PROMAC is among the more important federal programs for maize farmers in Chiapas, due to the significant amount of farmland within protected areas, on the state level there is a program called Solidarity Maize that is closely connected with the governor's office. This program ostensibly gives payments in the form of agricultural inputs to all maize farmers in the state. Given that fertilizers represent the greatest expense in maize farming in many regions of Chiapas, small farmers are generally in favor of Solidarity Maize and eager to participate. Unfortunately, the program reaches a relatively small portion of the actual maize farmers in Chiapas, while creating a massive informal market for sacks of fertilizers that are often exchanged for political allegiance long before reaching farmers.

In 2008, a group of farmers and advocates formed the Landrace Maize Network (*Red de Maíz Criollo*) in Chiapas in order to stem the loss of traditional peasant varieties of maize and defend the *milpa* production system. This group protested the fact that the supports from the state government through the Solidarity Maize program set small farmers on a course toward conventional, chemical-laden agricultural practices. The Landrace Maize Network achieved a commitment by the state government to offer organic fertilizers to those producers who request them, setting a new precedent for governmental support for alternative agriculture. Unfortunately, to date very few farmers know that they have the option to request organic farm inputs.

The farmers of 24 de Febrero have yet to receive support from PROMAC, despite their long-term commitment to growing traditional maize varieties, and they have not received support from the Solidarity Maize program either. In fact, PROCAMPO is the only government support that they receive. Despite being relatively close to population centers, and following the requirements to be considered in state and federal programs, they have been left out of the little support for small-scale agriculture that exists in Mexico.

## 9. Conclusions

The future is unknown, social and ecological drivers of change are linked, and periodic, qualitative change is part of life. That is one view of the world, carefully developed in resilience theory since Holling's (1973) seminal essay. Here we have posited two contrasting (but not exhaustive) food system possibilities, in part to demonstrate the openness of history. We do not see evidence for necessary evolution toward stable equilibrium in either social or ecological systems. Rather, the last several hundred years have shown that history is full of surprises, and theory of stages of development is often more hindering than helpful. In its insistence on the existence of the unknown, orientation toward emergent properties, and focus on feedback mechanisms, resilience theory is of extraordinary usefulness in social science.

Despite such impressive strides in systems thinking, we find the brave new world embraced by resilience science to itself be exclusionary in terms of possible outcomes for humanity. Far too often, the capital system is naturalized into the feedbacks of the social-ecological framework, rather than understood as a historical system that is liable to the same phases of growth, decadence, collapse and renewal as something qualitatively different. Indeed, in the present conditions of global financial crisis and historical highs of economic inequality, it would be quite blind not to accept the collapse of global capitalism as a historical possibility. With natural resource exhaustion and an exploitative human-nature relationship increasingly understood as inevitable contradictions of this economic system (O'Conner, 2001), the alternative stable states model is highly relevant for the testing of alternatives at distinct scales.

In *ejido* assemblies, the residents of 24 de Febrero have identified the directions that they would like the community to take. The local vision is of organic agriculture as a response to what appear to be increasing health problems, such as high blood pressure, diabetes, and cancer. The community has made collective decisions to begin a process of experimentation to combine what people remember of the practices used by past generations with technical advice from a research team of the Faculty of Agronomic Sciences at the Autonomous University of Chiapas. The role of local innovation is being filled (Milestad et al. 2010). But is this enough to pull the system toward a food sovereignty stable state?

The resilience literature identifies the need for adaptive governance (Allen and Holling, 2010; Folk et al. 2005). This can be interpreted in several ways, but the creation of public-private partnerships is often suggested, albeit in terms of "bridging organizations" or multi-stakeholder groups. In sum, governance for resilience is understood to take place in what Walker and colleagues (2002) call with refreshing honesty "more-or-less democratic, pluralistic, capitalist" societies. The resilience principle, as applied to social-ecological systems, has been applauded and feared because it normalizes—and absorbs all critique to—the neoliberal development model (Walker and Cooper, 2011). When adaptive governance is understood to mean increased private influence over formerly public spheres, especially natural resource management, then the objectives of its research agenda may well include building resilience to "shocks and disturbances" like market crashes, critical social movements, and dissent.

Unfortunately, history may show that the degraded system is global, and that what is "too big to fail" in the international economic system has indeed already failed, in terms of its social and ecological impacts. The destruction of global agrobiodiversity—a fundamental component of food system resilience—that took place during the last half-century has not been accompanied by a solution to world hunger, as more than one billion undernourished people make plain. If resilience is the "capability of a system to maintain its functions and structure in the face of internal and external change and to degrade gracefully when it must, (Allenby and Fink, 2005)" then perhaps the most prudent option would be to begin a wide debate about the graceful exit of the agribusiness model. The development of sovereign food systems at the local level requires cross-scalar interactions that should not be limited to farmer innovations, but include farmer-to-farmer networks, strong rural organizations, and redistributive public policy. If these requirements cannot be met within the neoliberal development model, then the next step is to ask what kind of transformation is necessary at the global level, beyond the narrow market valuation of Nature.

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