# "AGRI-CULTURAL PRACTICE AND AGROECOLOGICAL DISCOURSE IN THE ANTHROPOCENE: CONFRONTING ENVIRONMENTAL CHANGE AND FOOD INSECURITY IN LATIN AMERICA AND THE CARIBBEAN".

CHAPTER 7 IN MICHELA COLETTA AND MALAYNA RAFTOPOULOS (EDS) (2015/FORTHCOMING) *CONCEPTUALISING NATURE IN LATIN AMERICA: MULTIDISCIPLINARY APPROACHES TO ENVIRONMENTAL DISCOURSES*. ILAS: LONDON.

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# INTRODUCTION

In the realms of agriculture, food and the environment the 21st century is often described as one of impending limits, extremes and crises. Expansion of the agricultural frontier into forest land and the mechanisation and industrialisation of farming are contributing to previously unwitnessed rates of biodiversity depletion, while, overall, the food system accounts for approximately 50% of global greenhouse gas emissions (UNCTAD 2013). Indeed, the scale of human impacts on the biosphere is such that it is now detectable in the stratigraphy of the lithosphere, prompting Crutzen and Stoermer (2000) to propose a new geological epoch – the Anthropocene – emphasising the seriousness of the environmental challenges facing humanity in the 21st century. Peak oil, peak nutrients, soil erosion, declining biodiversity, global warming, climate change and extreme weather events threaten agricultural productivity, while market distortions provoked by growing demand for biofuels and livestock feeds, together with commodity speculation have resulted in two exaggerated food price spikes since 2005. Rapidly rising food prices have provoked acute nutritional crises for the World's 'bottom billion' (Collier 2007), almost 200 million of whom are resident in Latin America and the Caribbean. So, what does the situation look like in the region and what are the options for confronting and mitigating negative environmental change and food insecurity?

Latin America and the Caribbean (LAC) has some 600 million human inhabitants or approximately 9% of the world total and, while the rate of population growth is declining, at circa 1.3% per year, it remains above the global average and is not forecast to fall below it until after 2030 (FAO 2014). In terms of productive resources, about 37% of LAC's two billion hectares of land is dedicated to farming and almost 47% is covered by forests. The region also has abundant water resources: while it accounts for just 15% of the total global land area, it receives some 30% of precipitation. With respect to industrial inputs, on average some 110 kg of fertiliser are applied to every hectare of the region's crop lands, while in Latin America, excluding the Caribbean, each hectare is also dosed with 5.21 kg of pesticides each year (FAO 2014: *passim*).

This combination of land, water, labour and capital indicates that LAC is more than capable of producing enough food to feed its current inhabitants, with plenty of capacity to meet projected population growth. If we compare the region's biological capacity with its ecological footprint[2], we find that it has an ecological reserve or surplus of available resources over consumption of 2.9 ha per person, which compares very favourably with the global scenario, which exhibits a deficit of 0.9 ha per capita (GFN 2010). Despite this apparent ecological cornucopia, some 30%

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[2] Biological capacity or 'biocapacity' is the 'capacity of ecosystems to produce useful biological materials and to absorb waste materials generated by humans' while ecological footprint is 'a measure of how much area of biologically productive land and water an individual, population or activity requires to produce all the resources it consumes and to absorb the waste it generates' Global Footprint Network (http://www.footprintnetwork.org/en/index.php/GFN/page/glossary/)

of the total population continues to subsist on less than $2/day a figure that rises to more than 50% of rural inhabitants, some 35 million of whom fail to meet their daily food requirements (Berdegué and Fuentealba 2011). Furthermore, despite the fact that by 2010, more than 20% of the regional land surface had been assigned some form of protected area status, agriculture continues to have significant negative environmental impacts. Inappropriate cultivation and cropping practices lead to soil erosion, whilst the application of fertilisers and pesticides contaminates water, air and food itself. Expansion of the agricultural frontier and the replacement of biodiverse, peasant agroecosystems with monocultural, industrial production systems result in a continuing loss of biodiversity, while deforestation, soil cultivation, residue burning and animal agriculture all contribute to greenhouse gas emissions[3].

This chapter seeks to unpick this situation and explore two distinct proposals for confronting regional food insecurity and environmental degradation. The first, which will be only briefly outlined, is the 'global food security' model promoted by institutions such as the World Bank and the International Food Policy Research Institute (IFPRI). This relies on technological developments, increasing trade liberalisation, what is termed 'sustainable intensification' and the extension of social welfare programmes. The second, which will be set out in greater detail, is the altogether more radical proposal for 'food sovereignty' that has been put forward by the peasant and family farmer international, La Vía Campesina and promoted by a growing body of activist researchers and academics in the field of transformative agroecology (c.f. Méndez et al. 2015).

We will begin by exploring the environmental impacts of different agricultural practices, before moving to consider the benefits associated with low-external input, biodiverse agriculture. Once the productive and environmental characteristics of the region's agricultures have been described, we will return to consider the origins of the 21st century food price spikes and the proposals for global food security and food sovereignty. The chapter will close by setting out the key dimensions of what Altieri and Toledo (2011) have described as Latin America's 'agroecological revolution'.

## AGRI-CULTURES AND THEIR ENVIRONMENTAL AND HEALTH IMPACTS

Since the emergence of agriculture humans have modified natural ecosystems in order to obtain a large, nett, primary product to harvest. In order to maximise the output of useful products farmers seek to optimise the availability of nutrients, light and water to crop plants by controlling competition from non-crop species. Ecosystem modification usually involves the removal of most or all tree cover, especially in temperate regions, and as the agricultural frontier has expanded so the area of the Earth's surface covered by trees has contracted from a pre-agriculture estimate of c.75% to a current figure of just over 30% (FAO, 2010). As we have already noted, this process is less advanced in Latin America and the Caribbean, which still counts with almost 50% forest cover. Be this as it may, in the 20 years from 1990 to 2010 the

[3] Agriculture in LAC produces approximately 870 million tons of $CO_2$e annually (c. 18% of the global total), 65% of which comes from enteric fermentation in the guts of the region's livestock (FAO 2014).

region lost almost 100 million hectares of forest (c. 10% of the 1990 total): most of it to the expanding agricultural frontier. Trees store significant quantities of carbon and thus forest clearance contributes significantly to greenhouse gas emissions and hence, to global warming. It is not just the forests' trees that store carbon, the UN's 2010 Global Forest Resources Assessment estimated that, on average, forest biomass accounts for just 44% of total forest carbon, with a further 45% stored in soil organic matter and 11% in deadwood and leaf litter (FAO 2010).

According to Ruddiman (2003), the advent and expansion of agriculture and agrarian civilisations were responsible for a global mean temperature rise of almost 1˚C prior to industrialisation, implying that what Crutzen and Stoermer (2000) dubbed the Anthropocene began not with the Industrial Revolution, but some 5-8000 years ago with widespread forest clearance for agriculture. While Ruddiman's hypothesis has gained significant support and generated much debate, it is clear that the industrialisation of agriculture and globalisation of the food system based on fossil hydrocarbons has many additional negative environmental impacts as well as being a much more significant and problematic contributor to global warming than forest clearance alone.

As well as modifying ecosystems, agriculture has altered plant and animal genetics. Wild species have been domesticated and over successive generations those individuals with the most promising and useful characteristics have been selected and used to produce seed and offspring for subsequent crops of plants and animals. The Americas have endowed us with a raft of familiar agricultural crops: maize, climbing beans, squash, cotton, chilli, tomatoes, avocados, cocoa and vanilla were first domesticated from wild species in Mesoamerica, while the vast area covered by South America, from the Andes down through the Amazon Basin, offer evidence of the early cultivation of potatoes, tomatoes, cotton, sweet potatoes and numerous other roots and tubers, as well as peanuts and pineapples (Toledo and Barrera-Bassols 2008).

Over time, the on-going domestication of wild plants and animals and the selective breeding of crop varieties and livestock breeds have produced a significant expansion of agrobiodiversity. In Peru, there are as many as 4,000 or 5,000 different varieties of potato, each with its own flavour, shape, colour and texture, and each adapted to a particular ecological niche in terms of soil and climate. In just one municipality in Central Mexico, working together with local farmers, researchers from the Institute of Agricultural and Rural Sciences have identified no less than 60 distinct varieties of maize. The production and processing of crops, and the distribution and consumption of agricultural products has gone hand-in-hand with place-based, cultural learning and the establishment of a broad range of social institutions. In almost every seat of human habitation, distinct agri-cultures and agroecosystems have been developed and 'maintained through a mosaic of management practices that ... co-evolved in relation to local environmental fluctuations, and ... [have been] carried forward by both biophysical and social features ... including: genotypes, artefacts, written accounts, ... embodied rituals, art, oral traditions and self-organized systems of rules' (Barthel et al. 2013: 1142 – see also Chapter 2 in the present volume).

Toledo and Barrera-Bassols (2008) refer to these traditional agri-cultures as 'biocultural memory' and concur with Barthel et al. (2013) regarding their importance in terms of biodiversity conservation and future food security (see also IAASTD, 2009 and UNCTAD, 2013). Globally, of some '1.5 billion smallholders, family farmers and indigenous people' that occupy around 350 million small farms, roughly 50 percent employ agroecological practices and represent 'a testament to the remarkable resiliency of traditional agroecosystems in the face of continuous environmental and economic change – while contributing substantially to food security at local, regional and national levels' (Altieri and Toledo, 2011: 591). Indeed, according to a recent UNEP (2011) report, small-scale farmers produce 50% of the total global food production, with a further 25% coming from wild harvest, hunting and fishing. Altieri (2008: 5) claims that in Latin America '17 million peasant production units occupying close to 60.5 million hectares, or 34.5% of the total cultivated land with average farm sizes of about 1.8 hectares, produce 51% of the maize, 77% of the beans, and 61% of the potatoes for domestic consumption'.

The industrialisation of agriculture and the establishment of what McMichael (2009) has called the 'corporate' or 'food from nowhere' food regime has involved the simplification of agroecosystems and the transformation of diverse agri-cultures into homogenous agri-businesses[4]. In the process, crop, wild plant, animal, and human cultural diversity have all been greatly diminished:

'the rate of biodiversity loss due to ... chemically intensive monocultures is extraordinary. ... Entire habitats and [the] wild species associated with them ... have been lost or are on extinction trajectories ... and it is now well established that the current loss of biodiversity in agro-ecosystems also erodes fundamental ecosystem services that underlie the resilience of production, such as soil fertility, pollination and natural pest control' (Barthel et al., 2013: 1145).

The first stages of agricultural industrialisation began with mechanisation followed by 'the development of hybrid maize in the 1930s, [and] the expanding use of complete fertilizers and [chemical] weed and pest control technology following World War II' (Hildebrand and Poey,1985, p.ix). The success of these petroleum-based technologies in Europe and the USA led to international efforts to increase global food production by promoting agricultural industrialisation in the South. Of particular relevance to this endeavour were the constituent institutions of the Consultative Group on International Agricultural Research (CGIAR), which include: the Centre for the Improvement of Maize and Wheat (CIMMyT) in Mexico established in 1966, the International Centre for Tropical Agriculture in Colombia (1967) and the International Potato Centre in Peru (1971). In concert with national agricultural development programmes and significant funding from philanthropic organisations and aid programs such as the U.S.A.'s Alliance for Progress, these international institutions drove what subsequently became known as the Green Revolution, which extended technological packages of hybrid

[4] Compare the notions of 'agri-culture's and 'agri-business' with Millner's discussion of 'nature-cultures' in Chapter 4 of this volume.

seeds, synthetic fertilisers and chemical herbicides and pesticides throughout Latin America and more widely in the developing world.

Under optimum conditions industrial technologies returned remarkable increases in production. At the same time, however, increased productivity came at the cost of environmental integrity, social justice and long-term ecological and economic viability (Carson, 1962; Eckholm, 1976; Repetto, 1985; Woodgate, 1992; Vandermeer and Perfecto, 2013; *inter alia*). These and other studies show how industrial agriculture and the corporate food regime have concentrated land ownership, marginalised and impoverished small-scale farmers, depleted wild and agricultural biodiversity, polluted soils, water and the atmosphere, and transformed food from the most basic of human needs into globally traded commodities. Furthermore, toxic agrochemicals pose significant risks to the health not only of agricultural labourers but also urban populations living in proximity to large-scale agribusiness enterprises.

Wright's (2005[5]) benchmark study reveals the impacts of chemical-intensive, Green Revolution agriculture on the health and welfare of the untrained, poorly paid and ill-protected *campesinos*, without whom the agribusiness model would lose its comparative advantage. His analysis of export agriculture in Sonora, Mexico reveals how the exposure of *campesino* labourers to a wide range of toxic chemicals is so ubiquitous, that pesticide poisonings among the workers are almost a daily occurrence: an example of the 'super pollution' that O'Connor (1989) considered as one of the consequences of combining First World production technology with Third World working conditions. Neurotoxicological studies of modern, supposedly-less-noxious, agricultural chemicals clearly suggest earlier assumptions that sub-acute exposure to non-persistent organophosphate and carbamate-based pesticides had little compound effect on human health were quite false, indicating instead permanent nervous system damage with loss of reasoning and other mental-processing skills (Wright 2005, 336-340).

In addition, developments in the use of recombinant DNA techniques have allowed companies such as Monsanto and Syngenta to develop genetically modified strains of cereal and other crops that are capable of withstanding frequent spraying with herbicides such as Glyphosate or contain their own bioengineered pesticides. The former allow farmers to increase herbicide applications without risking damage to their crops, while the latter run the risk of creating pesticide immune pests. Furthermore, as with the so-called 'miracle' seeds of the Green Revolution, the new genetically modified varieties are covered by intellectual property right law, which holds the prospect of any farmer suspected of saving seed derived from patent protected crops, being dragged through the courts for breach of intellectual property rights.

'Treating plants and animals like so many assemblages of interchangeable parts is the ultimate stage of the application of … "the industrial mind" to agriculture and nature. Using this logic to more tightly chain farmers to the legal practices of industrial patent law and universalizing trade agreements extends the logic of the factory to the complex cultures of rural people and the winds and migrations of wild nature' (Wright, 2005: 351).

[5] Originally published in 1990

The potential for catastrophic impacts on human health that emerges when the agricultural regulation is captured by corporate agri-business is amply demonstrated by soya production in the Southern Cone. In 2003, Syngenta – one of six global seed corporations – took out an advertisement in the Argentine national dailies *Clarín* and *La Nación*, proclaiming 'The United Republic of Soya' (GRAIN 2013): a vast, imaginary, agri-industrial territory, unifying arable land in Argentina, Uruguay, Paraguay, Bolivia and Brazil. Argentina is the world's largest producer of genetically modified (GM) crops, accounting for more than 20% of all GM crop production. Since the 1990s, the Argentine State has rigorously promoted GM agriculture, revenue from which was vital to economic recovery following the country's crippling debt crisis and eventual default in 2001 (O'Toole 2014: 102-103). GM soya production follows a simple recipe: Syngenta's patented, Glyphosate-resistant soya beans are combined with a regime of fertiliser and herbicide applications. While the package is being promoted as 'environmentally-friendly' due to the claimed but contested low toxicity of Glyphosate and minimum tillage requirements, the size of the areas being farmed means that routine herbicide applications have to be carried out using light aircraft. In the suburbs of cities such as Ituzaingó in the province of Córdoba, to the west of Buenos Aires, less fair winds blow. Surrounded by immense oceans of GM crops, residents have been subjected to long-term repeat exposure to pesticide and herbicide spray drift.

We are all familiar with '*Las Madres de Plaza de Mayo*' and their struggles to recover, at least, their memories of the child victims of enforced disappearance during the brutal 1976-83 dictatorship. In the 21st century, regulatory capture has produced an Argentine agribusiness model that resembles a corporate dictatorship: a dictatorship that is spawning more bad memories for the future as it conducts what Broccoli (2015) characterises as the world's most grizzly 'toxicological experiment'. Today, another group of mothers is seeking justice, this time they are fighting for the rights of their 'contaminated children': the 'Mothers of Ituzaingó', who first reported the impacts on their children of excessive agrochemical use in 2001. Their struggle for justice is supported by popular gatherings, pesticide-poisoned people's organizations and peasants driven from their lands by the 'violence' (c.f. Shiva 1991) of the industrial model of monoculture GM crop production. By 2012 this pernicious production regime had spread over some 22 million hectares of Argentina's grain belt, with a resident population, not including the major cities, of approximately 12 million (Broccoli 2015). It was also in 2012 that the Mothers of Ituzaingó were finally able to set before the courts compelling evidence of more than 200 children diagnosed with cancers that it was claimed had been provoked by agrichemical poisoning. In a landmark ruling, 'the court in Cordoba found farmer Francisco Rafael Parra and pilot Edgardo Jorge Pancello guilty of violating regulations that banned the use of farm chemicals near homes' (BBC 2012). Encouraged by their success the mothers are now leading a national campaign against GM giant Monsanto's plans to build a seed processing plant at Malvinas Argentinas in the peri-urban area of Córdoba City (Broccoli 2015).

We began this section by describing how, for most of the past 10,000 years, agri-cultural practices produced a growing diversity of crop plants and domesticated animals. In closing we note that the globalization of industrial agriculture and the corporate food regime has resulted in: the loss of some 75 percent of crop plant genetic diversity, more than 30% of livestock breeds being at risk of extinction and fully three quarters of the world's food being derived from just five animal and 12 plant species (FAO 2004). Most if not all of these 12 species of crop plants have been subject to genetic engineering and depend not on the local knowledge and ecosystem services that motivate peasant agriculture but on standardised regimes of mechanical cultivation, agrichemical application and harvesting, all of which are dependent on dwindling reserves of fossil fuels. The profits from industrial food and fibre production are reaped by transnational seed and agrichemical corporations and large-scale agri-business enterprises, while national accounts are boosted by export revenues. The social costs of the corporate food regime's recipe for global food security are evidenced in ecological degradation, social deprivation, dietary deterioration and increasing risks to human health.

## From Industrial Agriculture to Transformative Agroecology

In contrast to industrial agriculture, agroecology begins not with the formulation of 'magic bullet' technological packages in corporate laboratories and agricultural research stations but with the agri-cultural practices of farmers in the field, seeking to learn from and build upon the ecological principles and place-based, bio-cultural knowledge that support long-term sustainable food and fibre production[6]. Agroecology as has emerged as a transformative, transdisiplinary and pluralist discourse and practice from deep-seated foundations. Sevilla Guzmán and Woodgate (2015) have sketched out some of these intellectual roots noting a number of recent Latin American and Caribbean experiences.

After several years working in commercial enterprises in Costa Rica and Mexico, in the mid-1970s, Stephen Gliessman took up a post as agricultural ecologist at the *Colegio Superior de Agricultura Tropical* (CSAT) in Tabasco, Mexico, which had been established 'to train the agronomists and test [Green Revolution] technologies on its experimental fields' (Gliessman, 2013: 26). During his time in Central America, Gliessman had been intrigued by the agri-cultural practices of his peasant neighbours and, as an ecologist, it became clear to him that rather than trying to override natural processes the local peasant farmers worked with them. He took these insights to Tabasco, where he delivered what was probably the first university course in agroecology: 'International summer courses in agroecology were offered in 1978–1980, a master's degree program in agroecology was begun in 1978, and research projects with the agroecosystem as the organizing concept and agroecology as the research process began as early as 1977' (ibidem).

During the 1980s a multitude of development NGOs sprang-up throughout Latin America as IMF-imposed structural adjustment forced states to cut back on public spending and close down rural development programmes. Towards the end of the 1980s NGOs from Chile, Brazil, Argentina, Bolivia, Colombia, Ecuador, Paraguay, and Peru, joined forces to form the Latin American Consortium on Agroecology and Development (CLADES). One of CLADES's technical

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[6] The interaction of farmer-scientists and researcher-activists involved in transformative agroecology reflects the 'valorisation of diverse forms of expertise within the production of future-oriented environmental knowledge' posited in Milner's contribution to this volume (see Chapter 4).

advisor was Miguel Altieri, a Chilean agroecologist from University of California, Berkeley. Together with the likes of Peter Rossett and Clara Nichols, Altieri developed the Consortium's relationships with rural social movements and development NGOs, providing them with agroecological advice and training. Since 1991 CLADES has published *Agroecología y Desarrollo*, a journal dedicated to making agroecological knowledge and experience available to institutions working to encourage ecologically and culturally relevant development practice, and providing a forum for debating the institutional challenges of sustainability. (See www.clades.cl)

Following the 1975 International Working Party for Peasant Studies at the University of Manchester, UK, where he had met and been encouraged by Teodor Shanin, Angel Palerm, Joan Martinez-Alier and Eric Wolf, Eduardo Sevilla-Guzman returned to Spain where, in 1978, he founded the Institute of Sociology and Peasant Studies (ISEC) at the University of Cordoba. ISEC became involved with the landless workers movement of Andalucía (SOC), supporting its members as they occupied and began to cultivate abandoned haciendas, using agroecological techniques they had learnt from the peasants that lived and worked around the old haciendas. The relationship between ISEC and SOC led to further important linkages with Latin American agrarian social movements, whose experience of struggle against the depredations of Green Revolution technologies and institutions made a significant contribution to the development of the militant perspective that characterises agroecological research and teaching at ISEC to this day (Sevilla Guzmán and Martinez Alier, 2006).

Cooperation among UC Santa Cruz, CLADES and ISEC resulted in the establishment of the first doctoral program in agroecology at ISEC in 1991, followed shortly after by a taught postgraduate programme at the International University of Andalucía. Many of today's key contributors to agroecological discourse have lectured or studied on these programmes, and the personal and institutional relationships that have developed through this long period of interaction and cooperation have facilitated the training and diffusion of agroecology practitioners, social movement activists, academics, and state functionaries throughout the Americas and beyond. These agroecological actors have contributed to the establishment and work of numerous institutions including the Brazilian Agroecology Association (ABA), the national umbrella group *Articulação Nacional de Agroecologia* (ANA), and the Latin American Agroecology Movement (MAELA), many of which come together in SOCLA, the Agroecology Scientific Society of Latin America.

Agroecology has developed through the coming together farmer researchers and activist scientists (c.f. Milner in this volume) within a significant and growing social movement for food sovereignty. Unlike certified organic agriculture, agroecology does not simply substitute chemical inputs with commoditised ecological amendments; it seeks to break farmer dependency on industrial inputs and the institutions of the corporate food regime, and to join with the producers and consumers of food in their struggles to defend themselves against the commoditisation of land, labour, knowledge, genetic resources and food. For Altieri and Toledo, agroecology comprises a technical, epistemological and social revolution that represents an overt challenge to 'neoliberal modernization policies based on agribusiness and agroexports' (2011: 587). It also seeks to create positive environmental change and remedy past degradation through appropriate agroecological practice rather than technocratic environmental management.

## The agroecology of agri-cultural practice

Traditional agri-cultural practices are built upon local, ecological knowledge and institutional resources, the maintenance of soil health, and crop and non-crop biodiversity. They display a number of key properties that are of vital importance to future food security and environmental sustainability.

1) Energy efficiency – low external input polycultures tend to be more energy efficient than high input industrial monocultures. This fact came to light in the dark years of the 1970s energy crisis, when researchers were keen to figure out how vulnerable the USA might be having passed its own point of peak oil production and being subject to an oil embargo imposed by the OPEC Arab states in response to US backing of Isreal during the Yom Kippur War. A key publication at this conjuncture was a paper published in *Science* by Pimentel et al. (1973), which demonstrated that the energy efficiency of corn production in the US grain belt was significantly lower than traditional *milpa* production in rural Mexico.

Martínez-Alier (2011) points out that for most of its history agriculture was 'the energy sector', because if produced greater quantities of energy in the form of agricultural crops than the amount of energy invested in their production. In his seminal text on traditional agriculture in Mexico and Central America (1987), Gene Wilken calculated that manual agriculture, without the use of draught animals, was capable of returning as many as 30 calories of crop output for every calorie invested in production. Of course, once part of the production has to be diverted to feed draught animals, the Energy Return on Energy Invested (EROEI) declines. Nevertheless, even when part of the work is undertaken using animal traction it is still possible to achieve an EROEI of as much as 10:1.

High external input, industrial agriculture, on the other hand, often requires ten calories of fossil fuel energy to produce just one calorie of food, transforming agriculture from a net energy producer to a net energy consumer. Clearly, such practice has no long-term future as it is entirely dependent on the availability of fossil fuels at a price (often subsidised) that makes it profitable. Furthermore, as the starting point for the neoliberal model of global food security or what McMichael (2009) calls the 'food from nowhere regime', it is responsible for significant additions of greenhouse gases to an already overheating planet.

2) Productivity – Ploeg (2013) points out that when discussing productivity and the potential of agroecological production to produce sufficient food it is vital to specify what type of productivity we are referring to. Proponents of industrial agriculture often claim that small-scale farmers and peasant producers are incapable of producing enough food to feed the world's growing population and demonstrate this through reference to labour productivity, which is greatly enhanced by the use of industrial inputs. For example, a mechanical reaper might be capable of harvesting eight hectares of maize in a single day, whereas it would take an individual around 20 days to harvest just one hectare by hand. In contrast, it is generally the case that low external input polycultures outperform monocultures in terms of land productivity.

Mesoamerican corn, beans and squash polycultures can produce almost twice as much food per hectare as industrial maize monoculture and twice as much organic residue for composting and turning back into the soil, thus obviating the need for synthetic amendments (Altieri and Toledo, 2011). Polycultural agroecosystems in general can achieve 20 to 60 percent more useful outputs per hectare than monocultures because, when the entire land surface of a field is covered by a mixture of useful plants with varying growth habits, the productive potential of available nutrients, water and light is maximised.

Furthermore, species and genetic diversity within the plot provide inbuilt protection against losses due to pests and diseases, avoiding the need to use polluting synthetic pesticides and fungicides. Vandermeer and Perfecto (2013: 82) illustrate this point very clearly when they recount the story of Guatemalan entomologist, Helda Morales and her research into traditional pest control techniques among the indigenous farmers of the Guatemalan Highlands. When Morales asked farmers about their problems with crop pests she was astounded to hear most folk reply that there were no pests. Knowing that numerous pests cause loses in maize monocrops, she instead enquired about the insects that inhabited the *milpas*. In response, the farmers reeled off comprehensive lists of all the potential invertebrate pests of both maize and beans. Asked why they did not consider these commercially significant species as pests, the Mayan farmers related aspects of milpa management that kept insect populations below levels at which they might be experienced as pests.

3) Carbon balance – Carbon is the key building block of life and a component of all organic matter. It is extracted from the atmosphere in the form of carbon dioxide ($CO_2$) by plants, which combine it with water it to create simple carbohydrates in the process of photosynthesis. It is returned to the atmosphere as a product of respiration, decomposition or combustion, or stored for longer periods in the woody tissues of perennial plants and more permanently in the organic and mineral fractions of soils. Carbon is therefore found in the crop and non-crop plants and animals that comprise agroecosystems and, perhaps more importantly, as we noted earlier in relation to forests, locked away in perennial plants and soils.

Agroecological production is based on the maintenance of a healthy, living soil, rich in organic matter and soil meso and micro flora and fauna. Biodiverse, polycultural systems, especially those that integrate annual and perennial crops, are continually sequestering carbon and storing it in both above and below ground biomass and subsequently in soil organic matter and minerals. Soil organic matter benefits farmers through the slow release of plant nutrients, reducing the need for increasingly expensive synthetic inputs. It also improves soil structure and water storage capacity, buffers soil pH, and moderates fluctuations in soil temperature. All these functions contribute to soil health and productivity. In addition to benefiting the farmer this means that agroecological farming has significant potential for climate change mitigation[7] (IAASTD, 2009; UNCTAD, 2013).



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[7] Contrast this with the REDD+ mitigation mechanism discussed by Anthony Hall in Chapter 5 of this volume.

Industrial agriculture, on the other hand, treats the soil as an inert substrate to which synthetic fertilisers are applied to supply plant nutrition. As a result, soil organic matter is depleted and in the process significant quantities of carbon are released to the atmosphere. Furthermore, in order to make its contribution to 'global food security' industrial agriculture depends on a whole raft of downstream and upstream institutions and activities. From the manufacture and employment of agricultural machinery and equipment and the synthesis of agrichemicals from oil, through the processing, packaging and storage of agricultural products, to their distribution to wholesalers and supermarkets and final preparation for consumption, at every node in its global web the industrial food system releases greenhouse gases to the atmosphere.

To add insult to this already significant planetary injury, it has recently been estimated that at one third of all food produced is wasted (FAO 2013)[8]. This figure takes a few moments to digest. One third of all food production uses water equivalent to the annual flow of the Volga, Europe's longest river, and 1.4 billion hectares or 28 per cent of the world's agricultural area. It is also responsible for contributing 3.3 billion tonnes of greenhouse gases to the planet's atmosphere every year. (op. cit.)

4) Resilience – In addition to climate change mitigation, diversified agroecosystems are more resilient to the increasingly severe and frequent extreme weather events that are associated with global warming. In the Central Highlands of Mexico, traditional Mazahua *milpa* production provides year round ground cover. The interlocking root mass of the maize, beans and squash plants, together with numerous wild species that are used as summer greens (*quelites*) for both human consumption and animal fodder, protect the soil from torrential summer rains. When synthetic herbicides are used, maize has to be grown as a monocrop, exposing the soil on steeply sloping hillsides to erosion and depriving people of important sources of dietary diversity and nutrition (Woodgate, 1992). Further evidence of agroecological resilience can been garnered from a survey of more than a thousand farms in Central America reported by Holt-Giménez (2001). The survey demonstrated that following the ravages of Hurricane Mitch in 1998, farms with biodiverse agroecosystems suffered significantly lower economic costs and recovered more rapidly than those where monocropping was prevalent, reflecting the inherent risk mitigating character of agroecological production. A more recent study of the impacts and aftermath of Hurricane Ike in Cuba (Machin-Sosa et al., 2010) demonstrated a similar situation, with agroecological production systems suffering approximately 50% fewer losses and recovering their productive capacity substantially faster than adjacent monocultural systems.

5) Adaptive capacity – As diversity confers resilience, in combination with traditional, place-based farmers' profound understanding of local ecological and cultural resources and relationships (c.f. Vandermeer and Perfecto 2013), it also imparts adaptability. Indeed, the hundreds of millions of traditional farms that continue to exist at the margins of the corporate food regime represent vital reservoirs of adaptive capacity that will be indispensible in the struggle to maintain food security in the context of declining biodiversity, dwindling oil reserves

[8] The Institute of Mechanical Engineers suggests this figure may be as much as 50% (IMechE 2013).

and accelerated global warming (c.f. Altieri and Toledo, 2011; Barthel et al., 2013; IAASTD, 2009; Martínez-Alier, 2011; UNCTAD, 2013).

## 'Transformative agroecology': beyond global food security

Méndez et al. (2013) distinguish two major agroecological perspectives or 'agroecologies'. In the 21st century, as the negative environmental impacts of industrial agriculture and the global food system have become more obvious, an interdisciplinary but top-down and apolitical 'agroecology-as-natural science' (2013: 12) has taken shape (c.f. Tomich et al. 2011; Wezel et al. 2009; inter alia). Its mission is to develop recommendations and ecotechnological packages directed at the greening of industrial agricultural production through ecological input substitution and what Pretty (1995) has called 'sustainable intensification'. Agroecology-as-natural science ignores the much deeper social and political foundations (Sevilla Guzmán and Woodgate, 2015) of 'transformative agroecology', which is transdisciplinary, participatory, politically engaged, and oriented toward social action focused on the transformation of agrifood systems from the bottom up (Méndez et al. 2013).

Transformative agroecology operates within a participatory action research (c.f. Fals Borda 1985) framework to generate understanding of agri-food system issues in order to inform transformative social action. The co-production of knowledge and shared understanding by activist researchers and scientist farmers does not lead to the promotion of technological solutions, but rather the 'co-motion' (Esteva 1987: 149) of systemic strategies directed at establishing and reinforcing beneficial socioenvironmental relationships. Such strategies seek to reduce dependency on external inputs of commoditised knowledge and petrochemical technologies, increase functional diversity and optimise productivity across provisioning, regulating, supporting and cultural ecosystem services. They also aim to enhance the quantity of energy output from each unit of energy input, to empower farmers and rural communities and to make a positive contribution to their goal of food sovereignty. Transformative agroecology thus clearly strikes at the heart of the 'global food security' model promoted by the corporate food regime.

Rapidly increasing food prices between 2005 and 2007 led to an additional six million people going hungry in Latin America and the Caribbean, while 2008 alone added a further 40 million people to the total global undernourished population. According to Torero[9] (2009) the food price spike and associated food insecurity were the result a combination of demand and supply factors. Among the demand factors he points to population and income growth, an increasing demand for meat products, and growing demand for biofuel feedstocks such as sugar cane, maize, soya and palm oil. In terms of supply, the high price of oil, poor infrastructure, low R&D investment and climate change were implicated. The International Food Policy Research Institute's policy priorities for combating the crisis and promoting global food security were, at the global level, reducing barriers to trade and combating market volatility while, at the national

[9] Director of the Markets, Trade, and Institutions Division of the International Food Policy Research Institute (IFPRI).

level, expanding social protection, taking action to improve child nutrition and achieving greater efficiency in linking small farmers to markets (op. cit.).

Although the global food security discourse does to some extent recognise the productive potential and importance of small-scale producers (IAASTD 2009; UCTAD 2013), IFPRI's (2002) plan of action for 'Reaching Sustainable Food Security For All By 2020' frames them more as hapless culprits of environmental degradation than victims of the violence of the new green revolution: 'poverty, low agricultural productivity, and environmental degradation interact in a vicious downward spiral, as desperately poor farmers mine soil fertility and climb the hillsides in an effort to survive' (2002: 4). The solution is pro-poor economic growth, involving 'small-scale, nonagricultural rural enterprises ... [and] ... [m]ore productive agriculture' (3). From IFPRI's position as a member of the CGIAR Consortium that defines and seeks to facilitate global food security through research and development, to be more productive farmers 'poor rural people need access to credit and savings institutions, yield-increasing crop varieties, improved livestock, appropriate tools, fertilizer, and pest management technology …' (*ibidem*). To contribute to food security they must be articulated with markets dominated by agribusinesses and regulated by the institutions of the corporate food regime.

Torero's (2009) paper at the 'World Food Crisis Conference' in London, stood in sharp contrast to that presented by La Vía Campesina Technical Adviser, Peter Rosset. In Rosset's (2009) view, the principle causes of the 2007/8 food price spike could be divided into long- and short-term factors. Over the long run neoliberal economic policy had been dismantling the capacity of the peasant/family farm sector to produce food, while promoting agroexport capacity to generate state income. Furthermore, structural adjustment had forced most debt ridden developing nations to sell off national food reserves such as those once held by Mexico's National Basic Products Company, CONASUPO. In the years immediately prior to the spike, Rosset emphasised the impact of speculative capital in commodity futures markets, growing demand for agrofuel feedstock, rising input costs, TNC and domestic private sector hoarding, speculation and forced exports.

Rather than seeking to achieve food security at a global level, La Vía Campesina champions an alternative model for moving towards a more sustainable food system, central to which is the right of every country or people to define their own agriculture and food policies. Food sovereignty demands the right to produce food for those that wish to do so and thus requires genuine agrarian reform and the protection of national markets against dumping by the advanced capitalist countries. It also proclaims people's right to adequate, affordable, healthy and culturally appropriate food. Furthermore, food sovereignty envisages the rebuilding of the productive capacity of peasant and family farm sectors, through the development of local agri-cultural practices and agroecological knowledge (Rosset 2009).

The voices of the global corporate food regime and supporters of 'global food security' criticise the food sovereignty model and, despite clear evidence to the contrary (Altieri and Toledo 2011; Holt-Giménez and Altieri 2013; Ploeg 2013; Wilken 1987; *inter alia*) doubt the capacity of local agri-cultures to produce sufficient food to feed the World's growing population. This censure rings somewhat hollow, however, as more and more ecotechnological fixes from 'agroecology-as-natural science' are incorporated into industrial production systems in pursuit of 'sustainable intensification'. Detractors also criticise agroecology for not scaling up. In response, Holt-Giménez and Altieri (2013) point to the massive mobilisation of state and private capital that was required to globalise the Green Revolution and the significant efforts and resources that are currently being poured into the promotion of commercial bio- and eco-technologies. They further suggest that '[a]sking "Why can't agroecology scale up?" begs the question, "What is holding agroecology back?"' (2013: 93). Besides the vastly unequal funding received by 'transformative agroecology', revisionist 'agroecology-as-natural science' (c.f. Wezel et al. 2009; Tomich et al. 2011) obscures agroecology's social context and neglects its political content.

## TRANSFORMATIVE AGROECOLOGY FROM THE BOTTOM UP

The development of capitalist agriculture and food production through the commoditisation of land, labour, water and most recently biodiversity and knowledge, while promoted as the solution to global food insecurity has, at the same time, resulted in the dispossession of small-scale farmers from biocultural resources that have been co-produced over generations of agri-cultural practice. The collapse of state-sponsored development and the return of economic liberalism in Latin America since the 1980s, have created the space and stimulus for a resurgence of peasant politics and direct action social movements (Altieri and Toldeo 2011; Martínez-Torres and Rosset 2010; Peréz Vitoria 2005; Ploeg 2009). These new agrarian movements demand access to and invade unoccupied land, and denounce the 21st century phenomenon of international land grabbing: foreign capital's rapid, large-scale acquisition of rights to vast areas in the South and the associated removal of peasant farmers (Magdoff, 2013). They also condemn what they characterise as the biopiracy of transnational seed companies, denounce the environmental degradation caused by industrial production and protest against the health impacts of toxic agrochemicals on those that work on, and reside is close proximity to, agribusiness estates. Their own responses to enduring poverty and food insecurity involve the practice of agroecological alternatives and political mobilisation in pursuit of land, water, seed, food, technological and energy sovereignty.

Altieri and Toledo (2011) identify five areas within Latin America where what they call the 'agroecological revolution' has become firmly established. In the Andean Region supportive institutions and government policy have given new life and meaning to the very significant biocultural heritage embodied in indigenous cultures and agroecosystems. In Central America, the *Campesino-a-Campesino* (Peasant-to-Peasant) movement has seen farmers sharing their knowledge of agroecological methods, allowing thousands of farming families to reduce their dependence on costly industrial inputs at the same time as increasing yields, improving nutrition and building resilience to the increasingly intense and frequent extreme weather events that plague the region (Holt-Giménez 2006)[10]. In Mexico, the extensive inheritance of communal land holding that resulted from the revolutionary Constitution of 1917 has facilitated the growth

[10] Also see Machin-Sosa *et al*. 2010 on the Campesino-a-Campesino movement in Cuba.

of sustainable rural communities and, of particular note, a very significant experience of successful community forest management (Woodgate, 2013).

In Cuba, following the collapse of the Soviet Union, the country's access to cheap oil, agricultural machinery and chemical inputs was drastically reduced, forcing national agricultural research institutions to explore low-input alternatives to the highly specialised industrial agriculture they had previously developed and promoted. In an extensive process of restructuring involving reforms to land tenure arrangements, the development of urban agriculture and the adoption of agroecological production methods, Cuba has been able to respond to changed circumstances and make substantial progress towards national food sovereignty (Funes Monzote 2009; Machin-Sosa et al. 2010). In the process much of the environmental damage inflicted by intensive industrial production has been ameliorated and, as already noted, resilience to climate change impacts has been enhanced.

In Brazil, agroecology has given rise to and become embedded in farmers' associations, social movements, universities and scientific associations and government agencies. The landless workers movement (MST - www.mst.org.br) was established to contest the concentration of land in the hands of the few and, since 1984, it has led more than 2,500 land occupations, settling at least 350,000 families on somewhere in the region of 10 million hectares of land. The Movement champions agroecological production methods and in 2006 established the Latin American School of Agroecology on MST land in the State of Paraná. It also organises an agroecological seed network to reduce dependence on transnational seed companies and facilitate food sovereignty (Altieri and Toledo 2011).

Like the MST, many national and regional agrarian organisations, confederations and social movements are members of the peasant and small-farmer International, La Via Campesina (LVC – www.viacampesina.org). Martínez Torres and Rosset (2010) trace the historical development of La Via Campesina from the early coalescence of numerous peasant and small farmer organisations and confederations in Latin America. Established as a global social movement in 1993, during the 1990s the movement's leaders gained access to international policy fora, rejecting NGO representation and making a space for authentic peasant voices to be heard. In the 21st century LVC has taken on a global leadership role for agrarian struggles and, through the politics of food sovereignty, presents a clear, potent and unified challenge to the corporate food regime and its neoliberal discourse of 'sustainable intensification' and 'global food security'. In short, 'peasants and family farmers have been able to build a structured, representative, and legitimate movement, with a common identity, that links social struggles on five continents' (2010: 150). In 20 years LVC has grown to encompass around 150 local and national organizations in 70 countries, representing about 200 million small-scale farmers in their struggle to 'defend community-based agroecological farming as a cornerstone in the construction of food sovereignty' (www.viacampesina.org).

At the local level La Vía Campesina works with member organisations to facilitate agroecological knowledge exchange through farmer to farmer processes and has established continental scale networks of trainers that organize regular encounters, where they share and develop the agroecological approach to food sovereignty. In the face of global capital's relentless pursuit of profit through land-grabbing, displacement of small-scale producers, and the patenting of seeds, knowledge, and technologies developed over generations of farming practice, in 2011 the second Americas Continental Encounter issued a declaration:

'Agroecology is Ours and is Not For Sale. Peasant agriculture is part of the solution to the current crisis of the system. In this context we reaffirm that indigenous, peasant and family farm agroecology [can] feed the world and cool the planet' (La Via Campesina 2011)[11].

Today, agroecologists, whether farmers, scientists or social movement activists (and many individuals operate in all three of these overlapping spheres of activity), are working in concert to defend rural communities and agroecological cultures against the negative social and environmental impacts of neoliberalism and the capitalist industrialisation of the food system. However, while the struggle for food sovereignty has become globalised, human experience of such impacts remains place-based and the local values, knowledges, practices and institutions of ecologically and culturally embedded people are indispensible to the (re)construction of ecological integrity and social justice. Throughout the length and breadth of the Latin America and Caribbean region a rich diversity of agroecological experiences are coalescing and making their distinctive contribution to the politics and practice of food sovereignty, part of a growing countermovement to the global corporate food regime.



[11] The decolonial politics of La Via Campesina seek to re-signify the campesinado in much the same way as those devised by indigenous peoples re-work indigeneity and re-cast the protection of environments as discussed by Radcliffe in the next chapter (8) of this book.

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