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Agroecological Transition in Cuba: Towards a Better Way of Life

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Report of the Organic Farming and Sustainable Agriculture Research and Fact-Finding Delegation to Cuba, May 4-12, 2006, organized by *Desarrollo Alternativo, AC,* Mexico[1]

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Abstract

The current financial and fuel crises threaten food security in poorer nations and among the poor in wealthier countries. Sustainable food production benefits communities and their food supply and can maintain farming systems in less developed agricultural regions. Many small farmers have long practiced organic agriculture, but face pressure to adopt green revolution farming, using chemicals and commercial seed. Some are resisting this, but lack the technology to apply organic methods on a larger scale. Cuba provides an instructive example of a nation that confronted a sudden food and fuel crisis by adopting organic agricultural technologies across production systems that vary tremendously in size and social organization. The agroecological revolution in Cuba evolved in the extreme conditions following the fall of the Soviet Union. Before this, Cuban agriculture was industrial, exporting cash crops and importing most human and animal foods. Almost overnight, Cuba was without agrichemicals, animal feed or fuel and was forced to switch to alternative methods using pest biocontrol, biofertilizers and animal traction. Cities now produce quantities of organic vegetables for the large urban population. Alternative methods are now widespread and have regional support systems, involving specialized centers and a network of farmers' associations and co-operatives. Local production systems play a notable role in building a sense of community. Despite these advances, Cuba continues to import much of its food and still faces significant challenges to food self-sufficiency.

Key words: Agroecology; biological pest control; food sovereignty; horticulture; research centers; self-sufficiency; social motivation; sustainability

Abbreviations and Techncal terms: ACTAF Asociación Cubana de Técnicos Agricolas y Forestales, Cuban association for agricultural and forestry technicians; ANAP, Asociación Nacional de Agricultores Pequeños, national association of small farmers; CIAP Centro de Investigaciones AgroPecuarias, centre for agricultural research, Universidad de Las Villas; CREE, Centro por la Reproducción de Entomofages y Entomopatogenos, Centre for Reproduction of Entomophages and Entomopathogens; ETTP, Estaciones Territoriales de Protección de Plantas, Regional Stations of Plant Protection; INIFAT Institución de Investigaciones Fundamentales en Agricultura Tropical; INISAV Instituto de Investigaciones de Sanidad Vegetal, INCA, Instituto Nacional de Ciencias Agricolas, National Institute of Agricultural Science; INRE, Instituto Nacional de Reservas Estatal, National Institute of State Reserves; *organopónico*, intensive urban agricultural unit; MINAG, Ministerio de la Agricultura,

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Minsitry for Agriculture, MINAZ, Ministerio del Azúcar, Ministry for Sugar, UBPC, Unidad Basica de Producción Cooperativa, Basic Units of Cooperative production.

Introduction

Global food prices have increased dramatically since in 2004, pushing millions into poverty and hunger (Holt-Gimémez, 2008; Nellemann et al., 2009). Global food systems are tied to volatile energy and financial markets, and further affected by increasingly unpredictable weather patterns (Holt-Gimémez, 2008; Nellemann et al., 2009). At the same time, we face increasingly frequent and far-reaching food safety scares (e.g. Hornby and Ransom 2009) and a global obesity epidemic (Nestle and Jacobson 2000). In the face of this perfect storm, people around the world are rethinking the food systems upon which their households, communities and nations depend (e.g. Burros, 2009; Melvin, 2009; Nellemann et al., 2009).

Cuba is considered a pioneer in development of sustainable food systems. In 2006, Cuba stood alone among world nations in meeting the twin criteria for sustainable development: living within the carrying capacity of the land and having a high quality of human life (Hails et al., 2006). Sustainable development has been defined as the long-term economical and environmental sustainable use of resources (Brundtland, 1987). Now the emphasis on the high quality of human life (IUCN et al., 1991) is an accepted index of a country's sustainability. The Human Development Index (HDI) is based on levels of literacy, education, life expectancy and per capita GDP (Hails et al., 2006). Though it is well-known that Cuba has high levels of education and health for all citizens (Deere, 1993; Wright, 2009), to what extent is it sustainably producing food?

Two complementary aspects of a nation's food production are **food security** and **food sovereignty**. Food security exists when all people have physical, social and economic

access at all times to nutritious safe food, sufficient to meet daily needs for a healthy life (FAO, 2002). In post-revolution Cuba, the emphasis on equality has meant that individuals have food security, but the nation may not be self-sufficient in food (Deere, 1993; Nova, 2006; Wright, 2009). For this, it must import little or no food while adequately sustaining its peoples' food needs (FAO, 2000). Short-term food security e.g. when donated grain to hungry people satisfies that hunger, is not sustainable in the long-term, although it may help sustain multinational profits by 'dumping' surplus grain produced in industrial quantities (Nyéléni, 2007). Food sovereignty, on the other hand, requires that small farmers have the basic human right to be in control of their food and be given fair market prices, while sustainably maintaining the environment (Rosset, 2003; Nyéléni, 2007). It means that all food producers must have land ownership and a say in food system polices at all levels (Nyéléni, 2007). The extent to which Cuba meets the criteria of either food security or food self-sufficiency and the measures required for food sovereignty are addressed in this paper.

Organic agriculture may be considered inherent to food sovereignty. The dependence of non-organic agriculture on industrially –and usually remotely- produced agrichemicals reduces the capacity of producers to control prices and production (Pollan, 2006). Because of its high dependence on petroleum-derived chemicals, non-organic agriculture may become more costly with soaring oil prices (Church, 2005; Hine et al., 2008; Hamer and Anslow, 2008; Wright, 2009). Green revolution agriculture embraces industrial-style use of agrichemicals and labor-extensive mechanized means of production (Borlaug, 1983) and has often been claimed as a solution to world food needs. It could meet the caloric requirements per capita of the world, yet it does not, as

food is not distributed equitably (Smil, 2000) and labor-extensive farming reduces rural employment and erodes rural culture.

In contrast, organic growing is more relevant to small-scale farmers, since the emphasis is on local resources and skills, which contribute to the ethical production of food (Crucefix, 1998) as well as to food sovereignty. If organic food is produced for local consumption, it contributes to sustainable farming (Rigby and Cáceres, 2001). Organic farming is labor-intensive and, in countries where salaries are high, is seen as a 'luxury' for those who can afford it (Bodini et al., 2006). The energy crisis has also highlighted the value of locally produced food, since both transport and packaging costs may be reduced (Bodini et al., 2006; but see van Hauwermeiern et al., 2007). The advantages to the environment of organic farming (Foereid and Høgh-Jensen, 2004; Hole et al., 2005; Niggli et al., 2007; Hine et al., 2008) further emphasize the need to reassess green revolution, or industrialized agriculture, especially as organic farming yields are often not less than those of non-organic farming, contrary to widely-held belief (Badgley et al., 2007; Hine et al., 2008). Agri-ecological systems, by their nature more participatory, are also likely to be more resilient to change (in markets, fuel prices etc) and therefore more sustainable (King, 2008).

Cuba is the only nation that has been forced to develop organic, labor-intensive farming as a national policy, following the withdrawal of Soviet support in 1990 (Vandermeer et al., 1993; Rosset and Benjamin, 1994; Funes et al., 2002; Pérez, 2004; Wright, 2009). Almost overnight, Cuba needed to provide its own food in the absence of fertilizer and other chemical imports. However, Cuba's highly developed human education and infrastructure was to play a key role in turning around its food economy in the time of

crisis (Deere, 1993; Rosset and Benjamin, 1994; Nieto and Delgado, 2002; Martín, 2002). Over two decades it has addressed this, with the support of advanced technological and agroecological knowledge (Funes, 2007; Funez-Monzote, 2008b; Wright, 2009). This paper documents current trends in Cuban sustainable and organic agriculture, specifically in the peri-urban context. Techniques in biocontrol of pests and biofertilizers are reviewed and the range of organic farms described. The successes of the agricultural improvements are set in the context of the uniquely Cuban societal structure. The organization of institutes, the education structure and informal methods of communication are highlighted, as they are considered integral to the success of the agroecological development. However, these successes are tempered by the still high level of food imports. Reasons for this are discussed with reference to Cuban research and with a view to progress towards food self-sufficiency.

Methods

In May 2006, a research delegation of 30 members of Desarollo Alternativo from 5 continents visited agroecological sites in Havana and Villa Clara provinces (see Chollett et al., 2007), These included: in Havana 2 farmers' markets; 6 organopónico* vegetable farms (1 state; 2 private, 3 suburban UBPC); 1 small private patio; 1 rabbit breeder; 1 agricultural consultancy shop; 1 polytechnic institute; 2 state Institutions (INIFAT and INISAV); 2 community projects; in Santa Clara:. 2 nurseries; 1 patio, 2 urban organopónicos; 1 agroecology farm; 1 agroforestry farm. .Seminars were presented by members of ACTAF, ANAP, MINAG and CIAP (Universidad de Las Villas, Santa Clara). .Observations made during the tour are substantiated by relevant published material

* technical terms, acronyms and abbreviations are explained at the start of the paper

updating and evaluating previous reports on Cuban agriculture in the early 1990s (e.g. Vandermeer et al., 1993; Gersper et al., 1993; Deere, 1993; Rosset and Benjamin, 1994).

Results

1. Historical Background

As a Spanish colony in the 16th century, Cuba was largely exploited for its tobacco, sugar and later coffee and citrus products (Thomas, 2001). Following independence in 1868, the early 20th century saw trade domination by the United States. By 1959, foreigners owned 75% of the land, with 5 US sugar companies alone owning ca 9% (Franklin, 1997). A lot of small farmers became landless and less than half the utilizable land was in intensive production (Murphy, 1999). Farms were very large, with about 9% of land-owners owning 73% of the land, on farms >400 ha (Nova, 2002). Sugar production dominated the economy and in the 1930s Cuba became the largest sugar producer in the world, exporting mainly to the US (Murphy, 1999).

With the revolution in 1959, all companies were nationalized and land was re-distributed, such that by 1963, no-one was allowed to own more than 70 ha (Franklin, 1997). The US responded by refusing to buy Cuban sugar and the Soviet Union offered to buy the remaining 1960 quota. Further nationalizations in 1961 led to the strengthening of the US embargo and Soviet co-operation and investment began in earnest (Franklin, 1997).

Soviet support hugely subsidized the Cuban economy. Cash crops were central to the agronomic economy; sugar remained the main export, along with coffee, tobacco and

citrus fruits, from 1960 to 1989, whereas 55% of food consumed in Cuba was Soviet-subsidized imports (Rosset and Benjamin, 1994). Even animal feed was 97% imported, largely maize and soya beans, as were all machinery and spare parts (Deere, 1993; Rosset and Benjamin, 1994). Petroleum and agrichemicals were also provided at low cost by the Soviet system and sugar was purchased well above market prices. Resultant profits drove the economy, facilitating the setting up of the state health system and an integral literacy and education program (Enríquez, 2000). More than 30% of tilled land remains devoted to sugar production (Cruz and Sánchez, 2003; ONE, 2008) and the sugar industry still holds high status, with its own ministry (MINAZ), alongside the Ministry for Agriculture (MINAG), though recently over half the sugar mills have been closed.

The disintegration of the Soviet Bloc in 1989 devastated the Cuban economy, eliminating 85% of its trade, including food and agriculture products and throwing Cuba into crisis (Rosset and Benjamin, 1994; Murphy, 1999). Cuban calorie consumption dropped by >30% to 1,863 kcal/day in 1993 (Cruz and Sánchez, 2003) and though egalitarian food distribution minimized starvation deaths, diseases associated with malnutrition were common (Nieto and Delgado, 2002) and pregnancies became very rare from ca. 1992 to 1997, due to malnutrition. The government imposed emergency measures, declaring a “Special Period in Peacetime”.

For the second time in the 20th century, Cuba had to turn around its agriculture, this time aiming at maximizing food self-sufficiency (Deere, 1993). It was like a war-time siege strategy, aided by the US blockade, still in place to this day (Perkins, 1993).

Socialism may be important in some form to facilitate government-led agroecological development (Benton, 1999). Certainly, the scientific, organizational and educational advances that enabled Cuba to feed itself in a time of crisis lie within the Cuban socialist system. However, this paper draws attention to the need for further adjustments in the Cuban system, notably incentives to increase production, to achieve food self-sufficiency on the island. A capitalist system dominated by multinational agricultural corporations, may seriously affect small-scale regional food production and sustainability (e.g. effects of NAFTA on Mexican food sovereignty, García et al., 2002; de Ita, 2003; Holt-Giménez, 2005).

2. Agroecological Change in Cuba

During the crisis period of the 1990s, Cuba re-modeled its production systems along agroecological principles. This 'alternative model' (Rosset and Benjamin 1994), for 'economic independence' (Fidel Castro, 1991), aimed for the most efficient use of:

- Land
- Human resources
- Organic fertilizers and crop rotation
- Biological control of pests
- Diversification of crops

Cuba also had to minimize its use of fuel (and therefore transport), chemical fertilizers and pesticides, all of which were virtually unobtainable.

While elements of this phenomenon are well documented (Rosset and Benjamin, 1994; Funes *et al*., 2002; Cruz and Sánchez, 2003; Wright, 2009), the agricultural transformation continues to evolve in both technical and societal dimensions. Involving a

fundamental shift towards *agroecology*, agriculture was central in promoting ecological, economic and social integration, with primary objectives of:

- self-reliance and sustainability
- local control over local resources
- farmer-driven appropriate technologies

(Funes, 2007)

These criteria are those of food sovereignty (Rosset, 2003), but the *government* policy shift to empower small farmers and develop regional research in chemical-free farming is without doubt unique to Cuba (Vandermeer et al., 1993; Rosset and Benjamin, 1994; Wright, 2009).

Following the 1993 disastrous sugar-cane harvest, a radical process of land reform began, with the conversion of the big Soviet-style collective farms to multiple forms of land tenure, including private farms and larger cooperatives that facilitate access to credit and resources (Enríquez, 2000; Fernández et al., 2007). The cities –where 74%, of the population dwells (Funes, 2002)- needed to be fed and farms are now also urban, connecting institutions with local food resources. Urban agriculture, along with rural small farmer production, has been the most successful over the last 20 years (Rodríguez-Nodals et al., 2007).

3. Technical solutions to the crisis

The ecosystem approach. Having no agrichemical inputs for crops, Cuba resorted to alternative agricultural methods, which eventually translated into an *agroecological* or "ecosystem approach" to growing food, working with, rather than against ecological

processes to manage crop diseases and pests. It is now recognized that diversified systems should mimic natural ecological processes to maintain a quasi self-sustainable balance (Altieri, 1995; 2002 a, b; García, 2002; Horn, 1998; Tilman et al., 2002; Morales, 2002).

Soil improvement and vermicompost. The ecosystem approach switches the focus from crops to the soils that support them. Agroecological methods build soil rather than deplete it. Cuban soils are often lateritic, poor and have suffered erosion and desertification (Treto et al., 2002). In the cities, soils are often absent, or full of rubble and good soil must be *created* to grow vegetables in derelict sites (Altieri et al, 1999; Cruz and Sánchez, 2003). All organic matter available on a farm is reused as compost. Humus is created from crop residues and animal manure, which reduces the practice of burning farm waste and helps close the energy cycle (Funes-Monzote et al., in press). This builds soils, balances pH for better plant nutrient uptake, helps retain water and provides food for microorganisms (e.g. Cairo et al., 2005; Díaz, et al., 2006). Many farmers also add red wriggler worms *(Eisenia foetida)* to compost to increase its nutrient concentration. This species can live in densities of up to 50,000 m^{-2}, bringing about rapid decomposition rates (Treto et al., 2002). Peak production of worm compost reached almost 80,000 t by 1998 (Treto et al., 2002) and by 2003, Cuba was reported to use 0.5m tons of worm compost a year (Lotter, 2003). With high N, P and K, 4 tons of worm compost replaced 40 t ha^{-1} cow manure in tobacco production, which increased yield by 36% (Gersper et al., 1993). Worm compost at 2-5 t ha^{-1} can replace or very much reduce the need for chemical fertilizer in high-production crops such as potato, maize and tobacco (Treto et al., 2002). Application of animal manure in mixed farms as

compost or worm compost can add from 49-73 kg N, 35-52 kg P and 56-83kg K $ha^{-1}yr^{-1}$ (Funez-Monzote et al., in press).

Biofertilizers. Cuban research has invested significantly in the development of various soil amendments. Inoculation of symbiotic *Rhizobium*, e.g. *R. japonicum*, provides up to 100% of nitrogen needs of many commercial legumes such as soya bean and cow pea (Treto et al., 2002). Unique to Cuba in the early 1990s, was the use of free-living *Azotobacter* for soil improvement, as is the commercialization of bacterial soil-improvers (Gersper et al., 1983). *A. chroococcum* and *Azospirillum brasilense* render nitrogen more available to plants and their presence in the rhizosphere of grain crops, cassava and sweet potato can stimulate plant growth, as they secrete metabolites such as vitamins and plant hormones, such as cytokinins and gibberellins (Dibut, 1998 in Treto et al., 2002). Many also inhibit the development of fungal plant pathogens. The use of Azofert can increase tomato productivity by >10% (Alfonso et al. 2005). Biofertilizers may also increase the active ingredients (flavonoids) in medicinal herbs (Sánchez et al. 2005).

Tropical lateritic soils are high in soluble iron and other metals, rendering phosphorus very insoluble and unavailable to plants. Bacteria such as *Pseudomonas fluorescens* and *Bacillus meghaterium*; species of *Achromobacter, Agrobacterium, Micrococcus, Aerobacter, Flavobacterium* as well as fungi such as *Aspergillus niger, Penicillium liliaceum* and various Actinomycete fungi render phosphorus –and potassium- more soluble in soils (Herrera, 1993). Soil inoculants of bacteria such as *Pseudomonas fluorescens* or *Bacillus* species, marketed as '*Fosforina'* (Treto et al., 2002), can decrease P fertilizer needs by 75% (Rosset and Benjamin, 1994; Lotter, 2003).

Mycorrhizal fungi, such as *Glomus* species, are also cultured and inoculated into soils or the rhizosphere to increase plant uptake of nutrients and stimulate seed germination (Treto et al., 2002).

The National Agricultural Science Institute (INCA) markets the biofertilizers as *Ecomic, Azofert* and *Rhizofert* (Treto et al., 2002). Farmers use various inoculants for their compost, according to available resources, the specific climate, topography and geology. In all cases a good supply of organic matter is critical, as it provides the nutrients for these organisms. 'Azotophos' (Fosforina and *Azotobacter*) is available to farmers at 9 pesos a kg and can be dissolved and applied as a foliar spray in early morning as a fertilizer. When added at a rate of 1kg per 45kg beans (*Phaseolus vulgaris*), 'Rhizofos' (*Rhizobium* and Fosforina) and Fosforina alone, increased productivity by 114% and 79% respectively (García, 2008). Farmers receive advice from ACTAF and soils institutes on composting, identification of inocula, pest treatments and using all farm resources to lower costs.

***Crop protection: from IPM to APM*.** Integrated pest management (IPM) was a response to environmental degradation associated with green revolution agritoxics and their reduced efficacy due to the "pesticide treadmill" syndrome (Hansen, 1987). IPM seeks to reduce pesticide use by substituting biological controls for chemical inputs and by careful targeting of pesticide applications in space and time (Maza et al., 2000; Morales, 2002, Pérez, 2004).

Cuban imports of chemical pesticides dropped from ca 40,000 tons (1974) to <20,000 tons per annum during 1975-1991, with the setting up of Regional Stations for Plant Protection (ETPPs) in 1975 (Pérez, 2004). This trend accelerated during the Special

Period and imports have dropped by a further 50% since 1991 (Pérez, 2004). IPM has been government policy since 1982 and Cuban researchers have long been leaders in the field of biological control (Nicholls et al., 2002; Pérez, 2004). But such work only became central to pest management during the Special Period. Currently, ca. 982,000 ha of crops are under biological control, saving ca US$ 30 million in pesticide imports (Nicholls et al., 2002).

Two main classes of biocontrol agents are used, entomophagous (insect-eating) insects and pest pathogens. The most widely used entomophagous species are wasps (e.g. *Trichograma* spp., *Tetrastichus howardi*) and flies (*Lixophaga diatraea* and *Eucelatoria* spp.) (Nicholls et al., 2002; Pérez, 2004). Reproduction and introduction of predators, especially lacewings and coccinelid beetles, is of particular importance in urban agriculture.

The principal insect pathogens applied as biopesticides are the bacterium *Bacillus thuringiensis* and fungi *Metarhizium anisopliae*, *Beauveria bassiana*, *Verticillium lecanii Paecilomyces lilacinus* and *Cladosporium* spp. (Pérez, 2004; Fonseca et al., 2005). *B. thuringiensis* is the most important and oldest used entomopathogen in Cuba (Fernández-Larrea, 1999) and production was 1,000-1,400 t p.a. between 1991 and 1999 (Pérez, 2004). Many entomopathogen nematodes have been isolated (Pozo et al. 2006a) and successfully used in control e.g. of the sunflower moth *Homoeosoma electellum* (Cruz et al., 2006) or scarab beetles, which prey on pineapples (Pozo et al. 2006b).

The fungus *Trichoderma* is well-documented as a biological control agent (e.g. Whipps *et al.,* 1988, Chet et al., 1998) and in Cuba was extensively researched, especially in

the 1990s. Pérez (2004) lists 21 Cuban papers documenting the use of various species and strains of *Trichoderma* on 33 different pathogenic fungi and nematodes affecting 15 different crops, including sugar cane, citrus, beans and flowers. Though more than 100,000 ha of tobacco, tomato and pepper are treated annually with *Trichoderma*, production is insufficient, partly due to the small-scale artisan production and the short shelf-life of the fungus (Pérez, 2004).

A uniquely Cuban approach to IPM are the Entomophage and Entomopathogen Reproduction Centers (CREEs). There are currently 272 CREEs (22 with MINAG and 50 with MINAZ) across the country, producing biocontrol agents to meet local needs, as well as 62 ETPPs (Pérez and Vázquez, 2002; N. Pérez, pers. comm., Jan. 2009). Operating in small-scale rustic facilities, the CREEs sell their products at low prices. At the INRE (Instituto Nacional de Reservas Estatales) organoponic site in Havana, technicians produce *Trichoderma* in three cramped rooms, using rice husks as a cheap and easily obtainable growth medium, for use on the farm and public sale alongside the vegetables. A bag of inoculum sufficient for 1 ha costs 8 Cuban pesos (about US$0.40). *Trichoderma* was the most commonly available biocontrol organism seen at organoponic points of sale.

In 1994 five biocontrol agents used on crops such as grasses, plantains, sweet potato, rice, cost <1% that of the equivalent chemicals (Pérez and Vázquez, 2002). Moreover, the former revenues remain in Cuba, whereas the latter would have gone to multinational pesticide companies (Pérez & Vázquez, 2002).

ACTAF colleagues in Villa Clara cited the success of biocontrol in cabbage –10% of vegetable garden area (Pérez, 2004)- which has all but replaced the 20 chemical

applications per crop cycle used prior to 1990. From 1995 to 1996, at a farm near Havana, the use of chemical pesticides on cabbage dropped from 24.3 to 13.8 kg ha^{-1} (Pérez, 2004).

While IPM techniques were broadly adopted from 1989-1993, the focus since 1994 has been on agroecological pest management (APM). This emphasizes pest *prevention* through integral agro-ecosystem management. Key elements include:

- The soil is treated as a living organism, not an inert substrate. Organic amendments, green manures and mutualistic "biofertilizers" improve soil fertility and nutrient uptake, ensuring well-nourished plants, which are more resistant to disease.
- Biological diversity to prevent pest outbreaks. This includes genetic and species diversity, of crops and associated species at the field scale and diversity of agroecosystems and communities at a landscape scale. Diversity hides plants from their pests, reduces the scale of pest outbreaks, and maintains pest natural enemies by providing them with habitat and food. Multi-cropping is also known to increase productivity (Tilman et al., 2002). Diverse agroecosystems include plants that repel pests (such as neem *Azadirachta indicia* or marigold *Tagetes* spp -observed in almost all sites visited- planted next to crops); or 'trap' them, by inter-cropping to attract pests away from the vulnerable crop -not yet widely developed in Cuba (Pérez and Vázquez, 2002; Pérez, 2004). Crop diversity is managed in time as well as space, with rotations designed to starve out pests (Casanova et al., 2002). At the INRE organopónico, lettuces –a quick rotation crop reducing time for

pests to proliferate- are harvested with their roots to remove harmful soil nematodes that cluster in the root ball.

- Well designed crop rotations and polycultures that maintain soil fertility, contributing to pest resistance. Maize and the legume *Canavalia* reduce weeds and increase soil fertility (Casanova et al., 2002)
- Cropping schedules that avoid peaks in pest and disease activity. Late planting –in autumn- of beans to avoid defoliation by the leafhopper *Empoasca kraemeri* (Murguido, 1995 in Pérez, 2004)
- Selection of crop varieties for resistance to pests and disease (e.g. tobacco varieties resistant to TMV (Espino et al., 1998); resistant grains, fruit, sugarcane, etc to nematode *Meloidogyne* species (Fernández et al., 1998)

These strategies recognize that chronic pest problems result from reductionist approaches which manage crops in isolation and largely through purchased inputs. APM sees farms as ecosystems of complex interacting components. The strategy is to develop an ecosystem-like balance with crops, pests and natural pest predators (Altieri, 1995). This approach is developing slowly in Cuba (Pérez, 2004); in the Alamar urban organopónico crops grow in a balance with the pests, there is no attempt to fully eliminate them (M. Salcines pers. comm.). By using chemical controls only when absolutely necessary, they minimize costs and maintain populations of the pests' natural predators.

Water and Irrigation. Availability of water limits Cuban agricultural production. Annual rainfall averages about 1300 mm and the November-April dry season seems to be extending. Rivers are short and carry relatively little water. A top government priority

after the revolution was to dam all possible rivers. Reservoirs and wells provide irrigation water. Over 50% of Cuba's water consumption is for irrigation, but demand far outstrips availability and agriculture must compete with industry and other sectors for water (Cruz and Sánchez, 2001).

Lack of equipment and fuel limit irrigation capacity. Modern foreign equipment is expensive. Cuba manufactures low-cost microaspersion systems which are used on many urban farms. Local invention ideas are not patented, but disseminated widely for use (Alfaro and Leyva, 2003). Diesel for pumps is expensive and a transition toward cleaner, more efficient electric pumps was a priority in 2006, the "year of the energy revolution" in Cuba.

Water consumption control measures are a priority. Venezuelan credit is helping refurbish leaky water networks –over 55% of Havana's water is lost via leaks (Cruz and Sánchez, 2001). New industrial and service facilities must have water conservation plans. Rum distillation plants produce nutrient-rich wastewater, now being channeled onto cropland. Drought plans are being developed for crops and drought-tolerant species especially of grain and beans tested (Moreno et al., 2001; Estrada et al., 2007; Soria et al., 2007). Plans include more localized irrigation, soaking seeds and filling planting holes with pre-soaked organic matter. Crop residues, coconut fiber and compost as mulch retain soil moisture.

Biogas. In 2003, Cuba consumed (and produced) 53,000 t oil equivalent of biogas of a total of 60,000 t for all of Central America (including Mexico) and the Caribbean (World Resources Institute, 2007). Residues from sugar-cane and distillery industries are used to develop biogas and the waste, with high fertilizer value, is returned to the sugar cane

crop or used in organopónicos (Suárez and Morín, 2002, Caballero et al., 2005). Farms also use biodigestors to produce cooking gas from animal manure. Several hundred farms now produce biogas. One farm in Villa Clara, recently diversified from a sugar-cane monoculture, produces methane in a two-chambered concrete drum; a pipe leads to the kitchen stove. Manure from 22 pigs generates cooking gas all year for three farms, with enough for two more. The family has a constant fuel supply and a nutrient-rich soil amendment.

Urbanization of agriculture. Cuban urban agriculture developed almost entirely during the Special Period. Since Cuba's population is mostly urban, the fuel crisis was minimized by growing vegetables literally at peoples' doors. With points of sale at each farm, the intermediaries were eliminated and wastage minimized. Food is supplied fresh to the consumer –"from the *cantero* to your table". The labor is also local, as the community itself often runs the farm.

During the Special Period, construction was put on hold and the vacant land transformed for horticulture. Topsoil and farmyard manure were brought in and, to minimize soil and water loss, raised beds (*canteros*) were developed with an irrigation system. The term *organopónico* was coined, imitating intensive hydroponics only in the water supply. Nutrients are organically derived from manure or a composting system.

2. Organizational structures

With the immediate need to provide food during the Special Period, numerous new structures, farms, institutions and organizations came into existence or were expanded

(Table 1). The Cuban government's financial and organizational support for this was essential.

Gardens and Farms.

These range from tiny private balconies with a few medicinal and culinary herbs to extensive gardens of several hectares (Enríquez, 2000). Many of the latter started as small plots, but as production increased and investment in the collective grew, they expanded into adjacent plots. Some are part of institutions.

Table 1. Summary of urban and peri-urban horticulture farms, based on Cruz and Sánchez (2001) and Rodríguez-Nodals et al. (2006). Unless stated, all are values for 2006.

Farm type	Average size (ha.)	Annual productiv kg/m^{-2}	Total are (ha.)	Total number
Autoconsumos (self-provisioning gardens)*	10.57	0.61	3,086	292
Community gardens				
a) *Microhuertos* (tiny plots)	0.128	5.79	12,774	100,000
b) *Parcelas* (plots)	0.221	6-8	30,975	139,960
c) *Huertos intensivos* (intensive garde	1.086	11.3	7,557	6,961
Organopónicos	0.310	18.44	1,183.4	3,810
Organopónicos de Alto Rendimiento (high-yield urban gardens)*	0.955	25.0	19.1	20

* data for November, 2000 (Cruz and Sánchez, 2001)

Autoconsumos Estatales (*self-provisioning gardens).* These were set up within an enterprise, hospital, school or ministry, as an extreme necessity to supply canteen food. By 1998, almost 400 existed in Havana alone (Murphy, 1999). By 2000, as food became more readily available, this number had dropped to fewer than 300 (Cruz and Sánchez, 2003), but many schools retain them for education as well as to supply school meals.

Community gardens. Private or state-owned land was developed for vegetable growing for immediate families or for local trade in or near urban areas. There are two types; the smaller ones of less than 5,000m^2 are called 'plots' (*microhuertos* and *parcelas*) and

produce vegetables mainly for one family. The larger ones (ca 1ha), called 'intensive-cultivation gardens', are farmed by several families collectively. All are supported by the Urban Agriculture Local Office or the Municipal Management Council (Cruz and Sánchez, 2003). With growing success, they often extend to support the local community.

One *microhuerto* in Playa, Havana, is an impressive small-scale example of a self-sustainable system. The family raises rabbits and African catfish and uses their waste as fertilizer for a variety of plants and fruit trees in the backyard. Completing the cycle, food waste from the household feeds animals and the plants. The main outside input is neighbors' waste.

Urban Organopónicos and High-yield Urban Gardens (Organopónicos de Alto Rendimiento). In the early 1990s, the local government gave vacant sites of 2,000 m^2 to 5,000 m^2, not directly usable for agriculture, to groups for collective farming to provide large amounts of vegetables for the local community (Cruz and Sánchez, 2003). Technical advice helped prepare the land for cultivation, since most had poor soil, covered in rubbish. The largest are in the suburbs such as Boyeros and Alamar in Havana, where space is more available (Murphy, 1999). Many are managed by the Metropolitan Fresh Vegetable Company (the Empresa Hortícola Metropolitana, EHM) and production is for sale (not autoconsumption). Five sell to the tourism sector (Cruz and Sánchez, 2003). Many are UBPCs (see below).

The vegetables produced are predominantly lettuces, spring onions, parsley, celery and other leafy vegetables that do not transport well. Bigger farms also produce soft fruit and vegetables, such as mango, papaya, tomatoes, and cucumbers. Many have an

agreement with a local pre-school, hospital or residential centre to donate food (Murphy, 1999) or supply basic produce at a low price.

Family farms. Rural farming also underwent transformation during the Special Period. The focus shifted from cash crops to feeding the nation. Within the small-farm sector, mixed farming, or 'diversified, integrated and self-sufficient' (DIS) systems are increasing, recycling farm waste for animal or crop feed (Funes-Monzote, 2008a).

The two private farms visited, supported by rural agricultural advisors, are typical of many others which are re-focusing to a mixed farming system (Funes-Monzote, 2008b; Funes-Monzote et al in press). One is reclaiming a dry savannah with a silvopastoral system using Eucalyptus and Caribbean pine *Pinus caribea* as shade for sheep. These in turn control weeds, especially the marabú, an invasive leguminous shrub (*Dichrostachys cinerea*). Eucalyptus was chosen as the soil is very poor and dry, but *Acacia* species may be used in future, since Eucalyptus impoverishes and dries out soil (see Nagy and Macauley, 1982; Shiva and Bandyopadhyay, 1983), whereas *Acacia* enriches soils with nitrogen. Both sheep and pigs provide manure (as 1:5 worm compost/manure) for the trees, including a tree nursery. The wood, harvestable after 8 years, provides fencing, building material and charcoal. The income includes a fixed state payment (30 pesos) per 10 liter can of charcoal, as well as a subsidy to clear the undergrowth and maintain firebreaks.

The second 9.58 ha farm, part of a CCS (Credit and Service Cooperative), is older and now in mixed production. Self-sufficiency includes the biogas reactor described above. Post-fermentation solids are spread directly onto the land. Formerly there was 1.5 ha sugar cane; now 0.5 ha organic cane is used mainly for animal feed. *Yuca* (cassava,

Manihot esculenta) is rotated with *boniato* (sweet potato, *Ipomoea batatas*) and maize. The *boniato* is extremely productive, each weighing around 2kg. Part of these crops is ground into flour for animal feed, stored in a granary of royal palm *Roystonea regia* timber and leaf thatch. Groves of royal palm provide shade for coffee for personal consumption.

Support Structures and Farmer Organizations.

Farmer organizations. ANAP, the Small Farmers' Association, founded in 1961, promotes the dissemination of information among small farmers. As the official Cuban body promoting the Latin American movement *Campesino a Campesino*, (Farmer to Farmer) (Holt-Gimenez, 2005), ANAP supports small farmer participation in international meetings and promotes the sustainable farming principles that underpin much of traditional *campesino* farming (Funes-Monzote, 2008b). By 2004, 3,052 facilitators and 9,211 promoters were involved in 85% of Cuban municipalities (Funes-Monzote, 2008b). ANAP promotes agroecology and encourages farmers to minimize risks by testing new practices on a small scale and allows for local decision-making, planning and implementation, putting control – and responsibility – at the farm level. This fosters both horizontal and vertical communication to share lessons learned.

Closely linked with this is participatory plant breeding. Developed in 2000, it involved over 20 institutes, universities, NGOs and international bodies during its early phases (Fé and Martínez, 2003; Pino et al., 2005) and is a very practical aspect of decentralisation. Local farmers and researchers exchange seed and knowledge about local varieties of crops, adapted to local conditions (Pino et al., 2005; Funes-Monzote, 2008). One farm visited in Villa Clara hosted two seed exchange days through ANAP.

Farmers from around the province meet to share seed varieties and exchange information about nutritional benefits and growth requirements. At one such seed exchange, over 117 bean varieties were brought together.

Agricultural Cooperatives. From 1975, farmers pooled their private land to form CPAs (Agricultural Production Cooperatives) and work the land collectively. By 1993 there were 1219 CPAs with 60,266 members with 772,500 ha (Alvarez, 2004). Members of CCSs (Credit and Service Cooperatives), created in 1982, work their private land individually, but form cooperatives to acquire credit and government services and to market their products as a unit. In 1998 there were 2781 CCSs with 163,800 members holding 962,300 ha (Alvarez, 2004).

The UBPCs (Basic Units of Cooperative Production) were formed during the Special Period from the large Soviet-style collective farms. Almost 3,000,000 ha -60% of state farms- were broken up into UBPCs and land under control of the State dropped from 82% to 24%. On average, UBPCs are less than 10 percent the size of former state farms. About 3000 have been set up since the early 1990's (Nieto and Delgado, 2002). The state still owns the land and the UBPC pays a small tax (< 1 peso) per m^2 under cultivation. Members have a direct say in running the collective, own all buildings, tools, seeds, etc. manage finances, loans and wages and share all profits (Murphy, 1999). By 1994 there were 2643 UBPCs with 257,000 members in both rural and urban areas (Alvarez, 2004).The UBPCs differ from the CPAs and CCSs in that they are not incorporated into ANAP. This places them at a disadvantage in accessing state resources and support.

Research and extension. The main institutions are under MINAG which aims to "guarantee the food security of the country and the sustainable development and international competitiveness of the agronomy sector for the benefit of Cuban society" (MINAG, 2005). The principal institutes are INIFAT (Institute for Research in Tropical Agriculture) and INISAV (Institute for Plant Health). They provide basic research for sustainable agriculture Spearheading much of the agricultural reform, INIFAT co-ordinates outreach work, is the locus for the National Urban Agriculture Group and administers the CREEs and seedling nurseries. MINAG recognizes *Patios de referencia,* or *excelencia;* "reference" or "excellence" gardens at municipal, provincial and national levels, which is another form of "farmer-to-farmer" education.

Aside from ANAP, ACTAF (Cuban Association of Farmers and Foresters), is key to the diffusion of information between institutions and cooperatives. Founded in 1987, it has 20,607 individual members, including members of 1,570 institutions (ACTAF, 2007). It has a decentralized structure, emphasizing training of small farmers and focusing on sustainability and community development.

CDRs (Committees for the Defense of the Revolution). Created in 1961, the CDRs are the basic organizational unit of Cuban society. They now support sustainable and agroecological food systems, as well as consumer nutrition and health education (Rodríguez-Nodals and Companioni, 2006). They also promote interest circles, for which any combination of the 28 subprograms of the MINAG Agroecological program (Funes-Monzote, 2008b), educational issues relevant to the Ministry of Education or small business issues can provide the basis.

3. Education

"Agriculture, without benefit of instruction, is imperfect"[2] –José Martí

Technical training. Cuba's agroecological revolution is predicated on its earlier educational revolution. Its education structure (Klein, 2004; Carnoy and Marshall, 2005) runs counter to knowledge transfer practiced elsewhere, where linear thinking is often oriented towards "success", measured in terms of material accumulation and where farm modernization focuses training and farming strategies on a business-oriented, large-scale production process, using the most "advanced" technology. This often leads to unemployment and lack of opportunities for many, to benefit only a few.

Cuba's educational system incorporates diversification and social, rather than individual aims. All Cubans have free education through graduate school and a large number of farmers are well educated, many following nine years' primary and intermediate education with further technical training. Specialized training for farmers increased during the Special Period (Wright, 2009). There is also an adult university for workers and farmers with over 240,000 enrolled in 2007/8 (ONE, 2008).

Inter-institutional linkages. Organizations such as ANAP, ACTAF and the Cuban Organic Agriculture Association (ACAO) work *with* ministries such as MINAG, MINAZ and the ministry for Science, Technology and the Environment (CITMA) as well as INIFAT and INISAV, to learn *from* and disseminate knowledge to, thousands of Cuban farmers and technicians (Altieri, 2002b; Funes, 2002; Funes-Monzote, 2008b). Egalitarian participation creates a large, skilled, technical base among farmers. Many have a keen interest in experimenting, gaining experience and sharing their knowledge. Cuba has thousands of promoters -farmers and horticulturalists- who use their acquired

[2] "La agricultura es imperfecta sin el auxilio de la instrucción."

knowledge and skills to train other farmers, developing the culture of agroecology across Cuba (Wright, 2009).

This requires integration of laboratory analysis, scientific knowledge, experimentation and practical experience. Support may be from a CCS and specific local networks, such as the CREEs –all of which *integrate* campesino knowledge into their research and training (Pérez, 2004; Funes-Monzote 2008b; Wright, 2009).

Consumer education on health and nutrition. An important goal of the agroecological program in Cuba is to improve the nutrition and health of the people, aimed at increasing life expectancy beyond 80 years. MINAG has many nutrition and health subprograms. The Food Conservation Community Project in Marianao, Havana, educates the public on preserving vegetables, diet information and a healthy lifestyle through courses, workshops, publication of books, magazines, radio, video and television programs (Figueroa and Lama, 2006). Another community project in Santos Suarez, a highly populated part of Havana, is run by a 19-year-old and gives workshops for all ages in horticulture, plant uses and preserving vegetables.

A growing issue in Cuba concerns diet-related illnesses. Now that there is more access to food, Cuban diets comprise an average of 3000kcal/day, including 80g fat. By 2005, 30.6% of adults and 14% of children under 5 were overweight and there is a rise in chronic, diet-related diseases like heart disease and diabetes (Carrillo et al., 2006). The high intake of high-calorie food may be partly related to residual psychological effects of times such as the Special Period, when food was scarce (Carrillo et al., 2006).

5. Markets

Labor markets. Production, highest in the smaller organpónicos (Rodríguz-Nodals et al., 2006), is incentive-driven; producers are more closely linked to the farm management than on the bigger state or former state farms (Funes-Monzote, 2008a,b). Many urban agriculture co-op members in 2006, earned up to 1000 pesos monthly, compared to a minister's salary of 450 or the national average of 330 (about $15 USD). The underlying principles of equality still prevail, as pay difference between the highest (even the director), and the lowest paid worker (e.g the cooks) is no more than 20%.

***Product markets*.** It is said that in Cuban cities and towns, the average distance that a person has to walk to buy fresh vegetables is 100 meters, but in Havana especially, very few points of sale are well-stocked. High petrol prices increase transport costs, affecting produce availability and prices. Food security for individual Cubans is assured in a variety of ways:

Monthly rations. Basic nutritional needs are provided by the state-run ration stores where Cubans get government-supported rations at very low prices. Basic foods such as beans, rice, sugar, coffee (115g) and oil are available for a few pesos. Children under 7 years and sick people get 1 liter of milk (0.25 peso) and each person gets 1 bread bun per day. Fresh produce is scarce but may include potatoes, eggs (10 each), frozen chickens (1lb each). Sick people are also entitled to reduced-price meat at 1.5 pesos kg^{-1} (Funes-Monzote et al., in prep.).

The Social Wage (subsidized meals). The state also subsidizes lunches, free at schools and low-cost (1 Cuban peso) at workplaces and the university. Some schools may even provide free breakfast. All working mothers have the right to child day-care and centers

provide free meals. Many other basic needs are distributed through the work place, such as housing.

Point of Production/Sale Stands. Maximum prices are set for these sales points through negotiations between MINAG, the neighborhood popular council and ANAP. Rice and fruit, delivered from peripheral farms, are often sold at these sales points.

Farmers' Markets. Two types of farmers' markets exist in Cuba. Some are "free" farmers' markets, established to encourage farmers to increase production by selling "surplus" produce (beyond the basic state mandates) at higher prices (Nieto and Delgado, 2002). Monthly farmers' markets, where the prices are reportedly much lower, also take place in some neighborhoods. Many "permanent" farmers' markets (about 30-40 in Havana) sell a wide variety of local produce (fruit, vegetables, ornamentals, medicinals, spices), and fresh meat (beef, pork, etc). Prices are very high; beef and pork are dearest at ca 30 pesos per pound; even 10-12 pesos per pound/ item is expensive for Cubans. These markets have a Consumer Protection Officer, and Consumer Rights & Responsibilities are prominently displayed. Spaces are rented from the state and sales must be direct from farmers to the consumers.

Discussion

1. An environmental challenge

Cuba still faces many challenges before it can attain self-sufficiency (Chollett et al., 2007). The main environmental factors of concern include soil degradation, effects of deforestation on soils and water catchments and terrestrial and marine water pollution (Díaz-Silveira, 1999; Treto et al., 2002). An increasing agri-environmental problem is the

amount of abandoned land, as much as 15.9% in 2005 (Nova, 2007a, b). Without the subsidized Soviet market, sugar production fell by one-half from 1992 to 1993 (Pérez, 1995), resulting in the closure of 85 of the 156 sugar mills. Today, only 45 remain open (Funes-Monzote, 2008b) and less profitable lands were abandoned. The Soviet era cattle (Friesian-Holstein) gave high milk yields but required imported feed (Nieto and Delgado, 2002). Without this feed, thousands died, unable to survive on grazing alone. The abandoned land became invaded by scrub and *marabú*. About 40% of pasture land is now covered by *marabú* (Funes-Monzote, 2008b). Milk and beef production dropped by half in the decade following 1989, the latter partly as male animals were pressed into service for animal traction (Nieto and Delgado, 2002).

Land recovery includes afforestation and using hardier cattle breeds. Ecological succession is slow on land formerly subjected to heavy, prolonged grazing or high-input production (Uhl, 1982, Ferguson et al., 2003) and active restoration intervention, e.g. replanting with nitrogen-fixing legumes (except *marabú*), is necessary in many areas. But such lands are far from the cities and farm labor is scarce (Funez-Monzote, 2008a).

2. Economic successes and challenges

Keys to the successes

Compared to the Dominican Republic, Cuba still has lower cash crop productivity, but its farmers have higher standards of health and education and all have land security with little risk of unemployment (Sinclair and Thompson, 2001). Cuban farmers are guaranteed financial aid in the event of crop failure from climatic events, diseases, pests and ‘criminal acts’ (González et al., 2002) and can take risks with new technologies that

farmers elsewhere could not afford. Overarching all, Cuba protects its economy against dumping, trade inequalities and external influences of foreign multinationals.

Key to addressing the food crisis was the decentralization of state structures during the Special Period (Funes-Monzote, 2008a). Cuban state support originated in the socialist revolution, which also gave all Cubans access to land. As the state controlled agricultural research, it could rapidly change a very centralized system to a more locally-focused decentralized one. Though alternative agricultural methods began in the 1980s, their incorporation to state policy was invaluable for their rapid development (Nicholls et al., 2002; Pérez, 2004). The high level of technical education, the organizing of co-operatives, soils institutes and the CREEs and the horizontal collaboration and information exchange, most of which were predicated on the socialist Cuban society also combined to make possible the shift to an agro-ecological approach (Nicholls et al., 2002; Funes-Monzote, 2008b). Assessing the future for a green Cuba, David (1999) demonstrates the advantage of the socialist approach over the capitalist. Cuban society engenders solidarity and respect for others, resulting in the success of many small-scale enterprises driven by, and for the local community. It is in this context that a more sustainable economy can be possible.

Food security or self-sufficiency?

However, a primary Cuban concern remains that of national food security (Nieto and Delgado, 2002). Though the Cuban transformation from extensive cash-crop industrial agriculture has been radical, has it been successful in terms of achieving self-sufficiency? In fact, this is not the case, as Cuba still imports about 50% of its food needs (Funes-Monzote, 2008a). Whereas, in 1985 Cubans' daily food intake was

largely from imported goods (53% of calories; 59 % of proteins), 20 years later, this had risen to 58% and 62% respectively, due to a drop in production of basic foods such as rice, beans, sugar, milk and fish (Nova, 2007a,b). In Cuba, the production only of potatoes and beans, on an area basis, exceeds the world average (Nova, 2006). Potatoes are one of Cuba's priority crops and received chemical fertilizer throughout the Special Period (FAO, 2003; Wright, 2009).

There are several reasons for this underproduction. One is the underutilization of land. Of the utilizable agricultural land, more than half is not cultivated, half of which abandoned (the rest are 'natural' pastures) (Nova, 2007a; Funes-Monzote, 2008a). A high proportion of these are state lands (52%); a further 29.5% belonging to the UBPCs (Nova, 2007a). This suggests low productivity and efficiency within these two sectors. The private sector, on the other hand, is more productive. Small private farmers (some in CCS) own 25% of the land, but produce more than 65% of Cuban food (Nova, 2007a; Funes-Monzote et al., in press). In the dairy industry, private farms own over 50% of the national herd (Nova, 2007a, Funes-Monzote, 2008a) and in 2007, milk production on private farms was 5.7 times as high as that of state farms (ONE, 2008).

The UBPCs in particular, though hailed as a radical reform in the early 1990s, are largely unprofitable (Nova, 2008). Recently, there has been a move to redress this, by selecting notably successful UBPCs as a reference for the development of others (Fernández et al., 2007). In July 2008, a new law allowed the redistribution of state, UBPC or other abandoned land for use in usufruct by any private person or group (Castro, 2008). This is a move to redistribute land to more motivated individuals, in recognition of the fact that smaller-scale farms are more productive and that UBPC

farmers generally have not considered themselves in sufficient ownership of the land to raise productivity (Nova, 2008). The creation of the UBPCs was abrupt and the workers found themselves collective owners of their farms almost overnight, but at a time of extreme economic difficulty (Nova, 2007c). In many cases, an intermediary enterprise has evolved to make decisions on sales, prices and investments, removing the farmers' sense of control of their produce (Nova, 2007c).

A lack of incentives has also inhibited productivity. in the UBPCs in particular, where workers have not felt the sense of ownership that would drive innovation and production (Nova, 2008; Funes-Monzote et al., in prep.). The 'linking man to the land' (*vinculación del hombre al* area) whereby an individual or small group was given responsibility for a specific area of a farm (Wright, 2009) was not a universal success. Whereas small farmers' knowledge is spread horizontally via the *campesino a campesino* network and through technical and seed interchange, this participatory involvement has been slow to spread to the state enterprises and UBPCs. Farmers identified lack of information transfer and training alongside a lack of incentives, as the main socio-economic limitations to production (Wright, 2005). Resistance to change towards multifunctional agroecosystems, both at local and national levels has also been a serious block in a development towards self-sufficiency (Funes-Monzote et al., in prep.). Other recent reforms that attempt to address some of these problems include further decentralization of agricultural institutions, increased farm gate prices and the removal of the caps on bonuses paid on top of basic agricultural salaries (Wright, 2009).

Organic agriculture and the need to change attitudes

The low productivity of the relatively intensive dairy or monoculture farms requires more radical re-structuring and greater agro-ecological training. Comparisons of intensive versus mixed farming systems throughout Cuba consistently showed that the closed-system integrated farms were more productive (Funes-Monzote et al., 2008; in press). The mixed farming approach whereby fodder for animals is grown on-farm and manure from these latter is used as fertilizer for crops and vegetables is efficient, especially in fuel use, since transport of fodder and fertilizer is minimal. Such closed-system farming should be expanded, if Cuba is to enhance its self-sufficiency in the light of a world fuel crisis (Wright, 2009). Whereas organic growing is almost universal in urban agriculture (Rodríguez-Nodals and Companioni, 2006), many crops are not yet fully organically grown; priority crops vary within and among provinces and, though agrochemicals were used very sparingly after 1990, 75% of cooperative farms visited in 1998-2005 used agrichemical fertilizers and 65% used some pesticides (Wright, 2005). Although alternative biological treatments exist, highly toxic chemical pesticides continue to be imported, albeit in low quantities (Pérez, 2008). There is still a common perception amongst Cuban farmers that low-chemical agriculture means not only low-input, but also low-output and therefore against national interests (Wright, 2005). Agrichemicals are associated with more affluent times and the lack of fuel regularly causes frustration (Wright, 2005). However, many farmers and technicians were aware of the greater potential for sustainable agriculture beyond the use of organic fertilizers and biological pest control (Wright, 2005). Of concern is the fact that chemicals are being used outside the strictly prescribed limits. Within the province and city of Havana -where use of agrichemicals is banned- a recent survey showed that 15% of hospitalized illnesses due

to chemicals were a result of agrichemicals (Pérez, 2007, 2008). However a significant proportion of Cuban farmers said they would return to using chemicals if they were available, although not to 1980s levels, since alternatives are now proven to work (Wright, 2005). CPA and UBPC members felt it depended very much on the individual collective whether it would continue to farm organically, given access to chemicals (Wright, 2005).

Conclusion

'*¿Y mañana que*?'[3] The commitment, social solidarity and organization of the Cuban people inspire confidence that alternative agro-ecosystems are implementable on a national scale and that the Cuban model can be transferred elsewhere, with the appropriate determination. The fundamental principles of the Cuban state are focused on the collective good, rather than on personal benefit, and are perhaps better disposed towards environmental reform than those of a capitalist state (Delgado Díaz, 1999).

It is difficult to measure how resilient the Cuban agroecological system would be in a global economic climate that favors trade over local self-sufficiency and ecological sustainability. Neoliberal globalization can discourage hope for meaningful change in the face of powerful forces that deprive people of livelihoods and dignity. The Bolivarian Alternative for the Americas (ALBA) can be cited as a model of trade based on solidarity among countries, and focused on development of a just society that could conceivably include a program for environmental as well as economic (self-)sustainability. Local

[3] Title of song by Cuban musician and chekeré player, Don Pancho Terry ("and to-morrow what?")

movements for sustainable farming are emerging in parts of the developed world, some modeling their aims on the Cuban example (Pfeiffer, 2006; Heinberg, 2007). But Cuba is so far unique in that a whole nation faced the crisis of acute food and fuel shortage.

Cuban food security has been ensured through egalitarian food distribution. Through the high level of education of the farming community and horizontal exchange of information, a certain level of control of food production is in the hands of the farmers. However, they themselves perceived a lack of training and information exchange as hampering production. The government control of prices, though buffering the nation against world trade controls, both hinders production incentives and allows unaffordably high prices at the free farmers' markets. Though technically farmers have use of their land in perpetuity, the sense of ownership and therefore control over production is only high in the small private farms. These factors need to be addressed to attain food sovereignty, but the agricultural efficiency needs addressing if food self-sufficiency is to be achieved. Cuba is much more urban than many countries and, as elsewhere, incentives to maintain rural communities working on the land are low, compared to the draw of city life. Perhaps the demonstrable ability of Cuban farmers and horticulturalists to earn a relatively high salary may encourage some, but it is hard to envisage outside the socialist system. In other, poorer countries, greater food sovereignty might be an incentive to maintain small farmers on the land. In rich countries, a better way of life might act as an incentive for a return to rural society. In both cases this could involve an organic and more sustainable agricultural system. But for the present, all we can say is Cuba is unique. It has demonstrated that a national agroecological system is possible

and it appears to have the potential to implement it fully and achieve food sovereignty for its farmers.

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