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Low-carbon food supply: the ecological geography of Cuban urban agriculture and agroecological theory

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Abstract Urban agriculture in Cuba is often promoted as an example of how agroecological farming can overcome the need for oil-derived inputs in food production. This article examines the geographical implications of Cuba's low-carbon urban farming based on fieldwork in five *organopónicos* in Pinar del Río. The article charts how energy flows, biophysical relations, and socially mediated ecological processes are spatially organised to enable large-scale urban agricultural production. To explain this production system, the literature on Cuban agroecology postulates a model of two distinct modes: agroecology versus industrial agriculture. Yet this distinction inadequately explains Cuba's urban agriculture: production in the organopónicos rather sits across categories, at once involving agroecological, organic-industrial, and petro-industrial features. To resolve this contradiction, a more nuanced framework is developed that conceptualises production systems by means of their geographical configuration. This provides analytical clarity—and a political strategy for a low-carbon, degrowth agenda.

Keywords Urban agriculture · Agroecology · Degrowth · Low-carbon transition · Energy geography · Cuba

Abbreviations

CREEs	*Centros de Reproducción de Entomófagos y Entomopatógenos* (Centres for the Reproduction of Entomophages and Entomopathogens)
FN	Field notes
GNAU	*Grupo Nacional de Agricultura Urbana* (National Urban Agriculture Group)
SEN	*Sistema Electroenergético Nacional* (National Electricity System)
UBPC	*Unidad Básica de Producción Cooperativa* (Basic Cooperative Production Unit)

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Introduction

Over the last decades the Cuban economy has gone through dramatic changes. It has not changed much in the sense of mainstream economic discourse where central planning and government control over private enterprise still loom large. Instead the changes have occurred in the sense of energy throughput. This has particularly been the case in the agricultural sector. During the 1990s, oil imports to Cuba decreased by 87 % after the collapse of the Soviet Union (ONE 2012).[1] Figures indicate that the use of agrochemicals declined by 85 % in cultivation of starchy roots (*viandas*), 72 % in vegetables, 55 % in beans, and 5 % in sugar cane between 1988 and 2007 (Machín Sosa et al. 2010). Yet many sources suggest that total production increased over the same period in all cases except cane (Machín Sosa et al. 2010; Altieri and Funes-Monzote 2012; Wright 2009).[2] A major contributing factor was a

[1] In attempts to replace Soviet energy imports Cuban domestic oil production increased during the 1990s, if only on a modest scale. In 2007, oil imports again increased, now arriving from Venezuela through the petro-alliance Petrocaribe.

[2] It should be noted that data on yields in Cuba are extremely difficult to assess. They are often too high, as to serve a political agenda, or too low, omitting produce sold on the black market. Energy data are likely more reliable as the infrastructure for imports and production allows for stricter centralised control.

reorganisation of farmland (Funes et al. 2002), but the reduction of energy throughput has also repeatedly been explained as a case of agroecological theory put into practice (Altieri 1995; Altieri et al. 1999; Altieri and Funes-Monzote 2012; Cruz 2006; Funes et al. 2002; Levins 2005; Machín Sosa et al. 2010; Nelson et al. 2009; Rosset et al. 2011).

Advocates of degrowth echo this claim. Degrowth is the clarion call of a social movement that promotes a voluntary reduction of energy and carbon throughput in economic processes. The aim is to mitigate climate change and promote social justice by transforming the economy towards a socially and environmentally sustainable steady state (Demaria et al. 2013; Martinez Alier 2009; see also Daly 1974). In academia, the concept has rapidly gained currency among ecological economists and political ecologists (Healy et al. 2015). And interestingly, Boillat et al. (2012, p. 600; see also Borowy 2013) assert that Cuban agriculture is "today's largest real-life experience of agroecological 'degrowth'." As such, it must be emphasised that it is an enforced real-life experience. It emerged at a time when cats and dogs disappeared from the streets for a lack of food and resulted from the conjuncture of the Soviet Union's collapse, the United States' blockade, the Cuban political system, and popular resourcefulness in the face of acute food crisis. Cuban degrowth has been far from voluntary.

Meanwhile, the low-carbon energy transition is emerging as a topical theme in human geography and energy studies (Jiusto 2009). A low-carbon transition, Bridge et al. (2013, p. 331) suggest, is fundamentally a geographical process as the need for energy services with confined carbon input "will require new ways – new geographies – of producing, living, and working with energy." A notable indicator of such geographical change came of out the recent Second International Congress for Urban Agriculture in Havana, stating that "[c]urrently 50 % of the vegetables and fresh condiments produced annually in the country originate from this [urban agricultural] productive system which has a solid agroecological base" (AIN 2015, my translation). In the early 2000s, in comparison, it was estimated that "90 percent of the fresh produce consumed in Havana … [was] produced in and around the city" (Companioni et al. 2002, p. 235 note 1). This indicates a dramatic transformation of the Cuban urban and periurban landscape from the time preceding the crisis of the 1990s.

This notwithstanding, agriculture figures only marginally in the energy transition debate. Energy transition studies focus on primary energy sources, electricity generation, transportation, and industrial production. In fact, urban agriculture has over all received surprisingly little attention from human geographers despite the evident spatial politics of food supply, urbanisation, and urban social justice involved (Tornaghi 2014). At the same time, Bridge et al. (2013) make clear that the geographical implications of low-carbon production systems still are poorly understood. In the context of transition, "low-carbon" indicates a shift from fossil-fuel dependence to renewable energy sources (Bridge et al. 2013; Nadaï and van der Horst 2010). In an agricultural system, the low-carbon ideal can therefore be translated to a minimisation of the use of fossilised energy sources throughout the production process—an ideal sharing common ground with the degrowth movement's objectives.

This article brings the geographical perspective from energy transition studies into dialogue with degrowth and agroecology. If Cuban urban agroecology represents degrowth, how are energy flows and ecological processes spatially organised to enable production? This question prompts a better understanding of both urban agriculture and low-carbon production systems by combining the two perspectives. The question, nonetheless, has its theoretical answer in the rich literature on agroecology. At heart, the answer is based on a distinction between agroecology and energy-intense industrial agriculture as two distinct modes of agricultural production.[3] In contrast, I shall argue that urban agriculture in western Cuba poorly fits this perspective. Based on fieldwork in five *organopónicos* in Pinar del Río, I show that these intensive urban gardens rather sit across modes, incorporating both agroecological and industrial features, despite coming close to an agroecological ideal. In more informal discussions, users of these terms are often aware that the situation is more sophisticated than the concepts suggest. Even so, the conceptual tools remain blunt to address this complexity. In this article I seek a more nuanced conceptualisation.

The article thus highlights a contradiction in agroecological theory. I try to resolve this by suggesting that urban food systems are better understood by emphasising their geographical configurations. I do this, first, by approaching farms dialectically. This means that a farm is understood not as a discrete, bounded place, but as a process maintained by the socioecological relations that it is part of; that is, as inherently linked to other places that sustain it and that it sustains (Harvey 1996; Robbins 2012). Second, I put the geographical concept of scale to work. This makes it possible to understand how these socioecological relations are arranged spatially into a productive agricultural system (Swyngedouw and Heynen 2003). An agroecological system, then, is an ideal type characterised by an internalisation of all socioecological processes within the farm as a spatial unit. This conceptualisation allows for more

[3] This distinction is not unique to scholars of Cuban agroecology, but has also been suggested by influential ecological historians such as Gadgil and Guha (1992).

analytical precision, I argue, and in addition provides an effective political strategy for degrowth.

The organopónicos—to introduce them further—are urban farms in which raised beds are filled with organic material to allow farming in areas with poor soil quality. Today they represent the most institutionalised and most intensive form of urban horticulture in Cuba. The organopónicos were introduced in 1994 as a government response to the popular movement of urban farming that emerged during "the Special Period", the deep crisis that ensued after the collapse of the Soviet Union (Rodríguez Nodals 2006). After Cuba's loss of political and economic allies, people in the cities began cultivating back gardens, parking lots, roof tops, demolition sites, patios, garbage dumps, and unused urban land with vegetables to feed themselves (Altieri et al. 1999; Wright 2009). Cultivating the city became an act of resistance to the crisis where people engaged in a spatial politics to control food supply. By re-scaling the food supply system, organic urban farming with large popular involvement contributed to a degrown urban food supply system relative to the system under Soviet dependency.

Agroecology versus industrial agriculture

To begin at the theoretical end, agroecological theory is formed around a basic dichotomy. In Rosset et al.'s (2011, p. 162) words the contemporary period is characterised "by an historic clash between two modes of farming: peasant agriculture versus agribusiness" (see also Altieri 1995; Cruz 2006; Funes et al. 2002; Nelson et al. 2009; Rosset and Altieri 1997; Rosset and Benjamin 1994; Vandermeer et al. 1993).[4] In peasant agriculture, which is largely synonymous with agroecology, the agricultural field is understood as an ecosystem rather than an interface for energy input and agricultural output. Consequently, agroecologists seek to mimic the function of an equilibrium ecosystem in the field. As Altieri (1995, p. 57) argues, "natural ecosystems reinvest a major proportion of their productivity to maintain the physical and … biological structure needed to sustain soil fertility and biotic stability. The export of food and harvest limits such reinvestments in agroecosystems, making them highly dependent on external inputs to achieve cycling and population regulation." The agroecological aim is therefore to set up and maintain a locally autonomous agroecosystem that to the highest possible degree closes ecological cycles within the farm through recycling and encouragement of predator–prey interactions, succession, commensalism, and so on.

In the early 1990s, the Cuban Ministry of Agriculture circulated a chart to its planning staff that similarly contrasted a "classical model" of farming with an "alternative model". Vandermeer et al. (1993, p. 6) and Rosset and Benjamin (1994, p. 30–31) reprinted this chart after a "fact-finding mission" to Cuba during the Special Period. In the classical model, the chart tells, agricultural production is dependent on external inputs and aims toward agricultural intensification and mechanisation with "cutting edge technology". Such technology includes imported animal feed, synthetic pesticides and fertilisers, modern irrigation systems, fuels and lubricants. "To satisfy ever increasing needs", the planners were informed, this model "has ever more ecological or environmental consequences, such as soil erosion, salinization, waterlogging, etc." The alternative model, in the opposite column, is characterised by community participation and cooperation, organic fertilisers, biological pest control and animal traction, as well as a "diversification of crops and autochthonous production systems based on accumulated knowledge".

Rosset and Altieri (1997) and Rosset et al. (2011) make a further clarification of this scheme arguing that organic farming as it is interpreted in Europe and North America misrepresents the shift from industrial to agroecological farming. Such organic farming is still largely based on monocultures and an input–output model at the scale of the production unit. The only difference from conventional Green Revolution agriculture is that petrochemicals have been substituted for organically certified inputs. Hence, to reduce organic agriculture to a list of allowed inputs that earns a product an "Organic" label leaves the current state of affairs unchallenged. Instead, this "technocentric" interpretation of organic farming privileges "the discourse of market choice, consumer sovereignty, and the individual" (Goodman 2000, p. 217). In so doing, certified organic farming stands in conflict with agroecological ideology on more than ecological terms. Through a transformation of ecological practice the agroecological aim is also a larger social transformation that challenges the political economy of agriculture (Funes et al. 2002; Desmarais 2007), again an aim shared with the degrowth movement (Demaria et al. 2013).

According to Wright (2009, pp. 199–200), the Cuban interpretation of organic agriculture has been strongly influenced by and conforms to the "Latin American agroecological school", which she contrasts to the "European certified organic model". "As one [Cuban] rural sector worker put it", she exemplifies, "'There is no alternative to sustainable agriculture. Both organic and Green Revolution agriculture are like agribusiness.'"

The essential question here from a geographical perspective is how to spatially organise energy and material

[4] This dichotomy is variously referred to as agroecology, permaculture, sustainable, organic, or alternative agriculture versus conventional, modern, classical, Green Revolution, or industrial agriculture.

flows to sustain production. Agroecological thinking revolves around the farm as a fixed point. In agroecological agriculture all energy sources and material processes are internalised in the farm. This, in turn, makes the farm self-sustaining and locally autonomous. This is possible by constructing an equilibrium ecosystem, enclosing ecological and energetic cycles, within the defined limits of the farm through social mediation. Industrial agriculture, on the other hand, "require[s] large amounts of imported energy to accomplish the work usually done by ecological processes in less disturbed systems" (Altieri 1995, p. 58). The energy needed for production thereby enters the farm from the outside in the form of synthetic fertilisers, pesticides, insecticides, herbicides, fungicides (all unwanted living things have their technological fix), diesel, lubricant oils, and genetically modified seeds. This supposedly makes the farm more vulnerable as production comes to depend on the institutions that uphold the displaced flows of inputs. In the case of Cuba, these institutions disintegrated in the early 1990s.

A farm is thus deeply involved with other places that sustain its fertility and biotic stability (see also Massey 1991). In spatial terms, the production system is relational: it constitutes a spatial frame where what goes on in one place only can be understood by appeal to how that place exists in relation to other places (Harvey 1996). The farm exists within a formation of socioecological relations. It is experienced as coherent and functioning when socioecological relations continuously enter from without (such as synthetic fertiliser being sprayed on a field) or connect within (such as husk being composted and returned to the field). To understand the organopónicos in Pinar del Río, accordingly, they must be related to the places that sustain them and to the places they sustain.

How energy and material flows are spatially organised as they are enrolled in a farm is part of what differentiates places from each other—what distinguishes an industrial farm from an agroecological. In both cases the socioecological flows are differently scaled. Scales are not ontologically given but are constructed as spatial fixations of socioecological processes. Scale distinguishes one place from the other by spatially organising them in relation to each other. "The production of geographical scale", Smith (2004, p. 196) argues, "provides the organizing framework for the production of geographically differentiated spaces and the conceptual means by which sense can be made of spatial differentiation." Thereby, Swyngedouw and Heynen (2003, p. 914) can conclude that the organisation of space through the production of scale, where socioecological relations are orchestrated into coherent agricultural systems, makes the "multiscalar configurations of monocultural cash-cropping agriculture … radically different from the socioecological scales of peasant subsistence farming." From this perspective an agroecological farm can be seen as an ideal type of a specific multiscalar configuration where all socioecological relations are scaled within the farm.

Pinar del Río's organopónicos

I now take these concepts along to Pinar del Río. Pinar del Río is Cuba's westernmost province and is also the name of a municipality and a city, the three nested within each other. My fieldwork took place January–March 2013 in five organopónicos in Pinar del Río city. The organopónicos, as all organopónicos across Cuba, worked according to an annual plan of 20 kilograms per square metre per year, adapted to local circumstances.

The organopónicos Ampliación Erea, Erea No. 1, El Vial, and La Pesca were *organopónicos arrendados*, or leased organopónicos. In these gardens, the workers used their monthly incomes from sales to pay for inputs, salaries, and land rent to the *Granja Urbana* (Urban Farm). The Granja Urbana was the municipal coordinating body for urban agriculture. Each Granja Urbana, in turn, was linked to the National Urban Agriculture Group (GNAU) of the Ministry of Agriculture. The Granja Urbana closely monitored sowing plans and harvest results in the organopónicos arrendados. Furthermore, all purchases of inputs by the organopónicos arrendados were reconciled through the Granja. The GNAU, among its activities, inspected each organopónico four times a year to evaluate their work, awarding graded diplomas as a moral stimulus, and to promote agroecological methods.[5] The GNAU also set the annual production target.

The organopónico Micro-Brigadas, in contrast, was a UBPC. *Unidades Básicas de Producción Cooperativa* (Basic Cooperative Production Units) were independent cooperatives that worked state land in usufruct. The UBPC annually made its own budget for revenues and expenditures and was connected to the Granja Urbana mainly to coordinate their work with other organopónicos and with the GNAU.

Fieldwork

The fieldwork consisted of interviews and conversations with workers in the five organopónicos. My key informants were the administrators who led work in each garden. They both worked in the organopónicos and represented them in the Granja Urbana, thereby having an overhead view. The

[5] GNAU, "Metodología de evaluación para Organopónicos contenida en la página 65 de los Lineamientos de la Agricultura Urbana y Suburbana para el año 2013" (henceforth, *Metodología*…). Evaluation guidelines distributed to the organopónicos through the Granja Urbana. Copy received from UBPC Micro-Brigadas.

interviews were conducted in Spanish and all translations here are mine from recordings. When it was not possible to record interviews, notes were taken referred to as Field notes (FN).

In UBPC Micro-Brigadas and El Vial, respectively, I also made maps together with two workers and the administrator. In one map the participants drew all the connections they could think of between their organopónico and the surrounding city, municipality, province, nation, and world. I initiated the exercise by indicating that I knew that produce was sold to the community at the organopónico's vending stall. This then indicated a flow of produce from the organopónico to the city and a flow of money from the city to the organopónico. The participants then expanded the maps with connections, for instance, to the market, peat bogs, and seed shops. In the UBPC they also drew a map indicating the relations they could think of within the organopónico; for example, a worker moving harvest excess to the compost and later compost to the *cantero* where vegetables were cultivated.

In addition, I directly observed and to some degree participated in daily organopónico work. Among other things, I witnessed the different methods used to produce organic materials in the gardens such as composts and vermicultures. I observed and participated in work routines such as sowing, weeding, harvesting, husbandry, sales, irrigation, and the installation of an irrigation system. I also took part in workers' meetings and every once in a while inspected storage facilities.

I was affiliated with the provincial university during the fieldwork, which gave me access to the organopónicos. A Cuban colleague, living close to the gardens and doing his weekly vegetable shopping in them, introduced me to the five administrators. After that I could move freely between the gardens on a daily basis and visit other organopónicos and the Granja Urbana as I wished. I judged that five organopónicos out of the city's 39 would strike a balance between getting to know the workers more profoundly and to have a larger sample.

From here on, I keep the organopónicos as the frame of reference, the fixed scale. In relation to this scale, I chart the spatial organisation of organic materials, seeds, water, electricity, pest management methods, labour power, and harvest that entered, exited, and cycled the organopónicos. In this way I reconstruct the ecological geography of the organopónicos dialectically through its scalar configuration.

Organic material

The organopónico farming method was invented to permit agriculture in areas where soils are infertile and hard to work without agrochemical input. To provide nutrition for the crops, the organopónico workers placed a mix (*mezcla*) of organic materials in *canteros*. The canteros, usually built with concrete blocks or stones, were the raised beds that are distinctive for organopónico production. The same soil mix was used for all crops, although some cultigens such as radish needed softer soil for their roots to develop.[6] The same soil ingredients were used in all organopónicos, although the quantity of each material could vary.

Compost

All gardens had active composts (*compós*) where production by-products were deposited for decomposition. The amount of compost that was possible to produce in each organopónico varied. In Ampliación Erea, where a large area was devoted to banana cultivation, banana residues provided plenty of potassium rich compost.[7] Ampliación Erea therefore had more biomass to compost in comparison to La Pesca where all space was dedicated to canteros. Consequently, La Pesca was more dependent on other sources of organic material.

Earthworm humus

According to guidelines from the GNAU, all organopónicos had to have a vermiculture (*lombricultura*) supplying earthworm humus (*humus de lombriz*) in "a nearby area".[8] La Pesca and El Vial had their own vermicultures whereas Ampliación Erea and Erea No. 1 shared a vermiculture located in the latter. In time for an inspection by the GNAU in late February 2013, the workers in Ampliación Erea were activating a vermiculture within their own organopónico to increase their evaluation result. The UBPC, in turn, was experiencing problems with their vermiculture, which had dried out, and was reactivating it with new worms. The vermicultures were fed with harvest by-products and livestock manure.[9]

Chicken manure

One of the most important sources of soil fertility was chicken manure (*gallinaza*). This was acquired from chicken runs outside the city. The organopónico workers were unsure of whether the chickens fed on organic feed or not. As large quantities of chicken manure were used, it

[6] Interview, administrator of UBPC Micro-Brigadas (MB), 25 January 2013.

[7] Interview, administrator of Ampliación Erea (AE), 29 January 2013.

[8] *Metodología…*.

[9] MB, 25 January 2013; administrator of El Vial (EV), 4 February 2013.

was bought from several chicken runs located both within the municipality of Pinar del Río and in neighbouring municipalities.[10] The manure was transported to the organopónicos in lorries running on diesel or petrol.

Peat

When the amount of compost was insufficient, peat (*turba*) was purchased from a peat bog in neighbouring municipality San Luis. Peat was also transported to the city in lorries.[11] Crosby (2006, p. 61), the environmental historian, calls peat "the adolescent fossil fuel" as it requires thousands of years to form.

Livestock manures

Furthermore, the workers used livestock manures (*estiércol vacuno*) both to feed the vermicultures and to mix with compost for use in the canteros. The UBPC had the most diversified use of manures. UBPCs were permitted to sell a wide range of products and services, in contrast to the organopónicos arrendados that only could sell vegetables, roots, and fruit.[12] Thus, the UBPC had recently started to breed rabbits and pigs to sell for slaughter as alternative protein food sources. At the end of my fieldwork, the UBPC had seven rabbits with seven babies and three pigs. In the meantime, all faeces were collected and used as manure. The UBPC also had four horses used for traction and transport, whose dung was used as manure. All the animals fed on organopónico produce.[13]

El Vial, in turn, had four cows and a horse that grazed in an open area outside the organopónico enclosure. The dung was used to feed the vermiculture. Erea No. 1 and Ampliación Erea bought cow manure from farmers outside the city.[14]

Sawdust

Sawdust (*asserín*) could be added to the soil mix to make it more porous and to increase drainage. The organopónicos rarely purchased sawdust, however, as it usually accompanied the chicken manure. When the chicken farmers swiped the floors to collect manure, sawdust would come along.[15] The administrator of Erea No. 1 explained that they earlier used to cover the paths between the canteros with sawdust to reduce the growth of weeds.[16]

Limestone

The administrator of El Vial also explained that they sometimes bought limestone (*cal*) from a lime quarry in Santa Lucia in neighbouring municipality Minas de Matahambre.[17] El Vial was the only of the five organopónicos to do this.

Cachaza

Finally, Companioni et al. (2002) note that *cachaza*, a mud consisting of small fibres filtered apart from sugar cane juice, is one of the most extensively utilised organic fertilisers in Cuba, in part as the sugar industry has kept it available in large quantities. Four percent of the sugar harvest results in cachaza (Treto et al. 2002). Yet cachaza was not used in any of the five organopónicos in Pinar del Río. When I brought up the topic, the administrator of El Vial explained that "No, it's too far off; cachaza is in San Cristóbal, in Bahía Honda, very far. It's good, but it's too far off [to get]. Now it's practically out of the province."[18] The other administrators gave similar answers: the sugar centrals were too far away to make it practically or economically sound to get hold of cachaza. However, if it were accessible they would gladly use it.[19]

The absence of cachaza in Pinar del Río's urban agriculture is as interesting to note as the actual use of other organic materials. All used organic materials were either produced within the organopónicos (compost, vermiculture, livestock manures) or purchased from places located within Pinar del Río province (chicken manure, peat, cow manure). In the latter case, the organic material was transported to the organopónicos in lorries fuelled with diesel or petrol, which was supplied through internationally scaled trade relations. Cachaza, on the other hand, was not used as the scaling of this practice would displace the source of organic material too far from the organopónicos. Thereby, in terms of organic material and soil fertility, the organopónicos were provincially self-reliant. Still, the scaling of the socioecological relations that enabled production extended out of the city. These scalar relations were maintained by fossil-fuelled transports.

[10] AE, 29 January 2013; EV, 4 February 2013; administrator of Erea No. 1 (EN), 18 February 2013 (FN).

[11] MB, 25 January 2013; AE, 29 January 2013; EV, 4 January 2013; EN, 18 February 2013 (FN).

[12] MB, 20 February 2013; AE, 29 January 2013.

[13] Interview, worker at UBPC Micro-Brigadas, 25 January 2013.

[14] AE, 29 January 2013; EN, 18 February 2013 (FN).

[15] MB, 25 January 2013.

[16] EN, 18 February 2013 (FN).

[17] EV, 4 February 2013.

[18] EV, 4 February 2013. San Cristóbal and Bahía Honda municipalities belonged to Pinar del Río province until 2011 when they became part of the new province Artemisa.

[19] AE, 29 January 2013; EN, 18 February 2013 (FN).

The fate of impoverished soil

The same soil mix was reused for several rotations with different crops in all the organopónicos. When the soil was finally impoverished in El Vial, it was disposed of in an area outside the organopónico.[20] In the UBPC, equally, the administrator described that "[a]fter some time or for larger crops like moringa [*moringa*], the soil is exhausted and we have to throw it away. It is put in a place away from the organopónico."[21] The administrator in Erea No. 1, in contrast, explained that they put impoverished soil in a large heap by the garden gate and mixed it with chicken manure, compost, and peat to make it usable anew. At some point the heap must become too large, I asked, but then it was just a matter of selling the good soil to a *finca* or a cooperative somewhere.[22]

In sum, the methods of soil management differed slightly among the organopónicos, but the spatial flow of organic materials had the same direction in all of them: new fertile matter entered the gardens while surplus and impoverished soils exited.

Seeds, water, and electricity

Next to organic material, production depended on the supply of seeds and water to the organopónicos. The use of irrigation systems, in turn, was dependent on electricity to propel the water pumps. This connected the organopónicos and their produce to electricity generation and distribution systems.

Seeds

The workers produced some seeds on their own within the gardens. Lettuce (*lechuga*), string beans (*habichuela*), chard (*acelga*), and radish (*rábano*) could generally be produced in the organopónicos. Tomato (*tomate*) seeds were also produced in El Vial.[23] On one occasion Ampliación Erea's administrator showed me their seed production and explained the reason behind it primarily as a matter of quality:

> Look, here we are making some seeds. Chard, lettuce – so we don't have to buy it – in this way we know what we are planting. It's good quality lettuce. … String beans, chard, we can make pepper [*pimiento*] – in all its varieties – aubergine [*berejena*]. … Also spinach [*espinaca*] we can reproduce.

Yet the bulk of seeds was acquired from the Granja Urbana's seed shop, the *Tienda de Semilla*, or in the case of the UBPC sometimes from a contractor in Consolación del Sur municipality. Plantlets were also bought from the Granja's greenhouse, the *Casa de Postura*. Generally it was easier to buy seeds, Erea No. 1's administrator explained, as they were produced in places designed for the purpose. According to him, all seeds for purchase were produced nationally, but I could not confirm this.[24]

Hereby, depending on species and local circumstances, the seed supply process was in some cases internalised in the organopónicos. In other cases the organopónicos depended on relations that were scaled far off from the gardens, although the Cuban island was territorially self-supplying in the organopónico workers' understanding.

Water and electricity

For a continuous water supply, the workers relied on other sources than rainfall. Rains were heavy during the hurricane season (c. June–October), which could make cultivation difficult due to the hard rainfall. The rest of the year they depended on irrigation technologies. The mode and state of irrigation varied among the organopónicos and irrigation was in some cases the greatest obstacle to production. None of the organopónicos had financial resources to buy an irrigation system. The only way to obtain one was through an international aid project administered by the GNAU.[25]

La Pesca was the only organopónico where the workers were fully satisfied with their irrigation system. They had recently received a system with eight sprinklers through a Brazilian-funded project.[26] The irrigation system in El Vial was also intact but its design made it hard for the workers to intercrop plants.[27] The UBPC truly suffered from problems with the irrigation system. Their system used to cover the entire garden, but it had broken several years ago and now only covered the organopónico's northern half.[28] Erea No. 1 and Ampliación Erea had until my fieldwork irrigated their gardens manually with hoses; yet I could witness the installation of a large water tank, water pipes, and sprinklers in Ampliación Erea.[29] Both organopónicos were receiving irrigation systems through projects. A

[20] EV, 21 February 2013 (FN).

[21] MB, 7 February 2013.

[22] EN, 23 February 2013 (FN).

[23] EV, 24 January 2013 (FN); EN, 18 February 2013 (FN); AE, 29 January 2013.

[24] EN, 18 February 2013 (FN).

[25] MB, 7 February 2013.

[26] Interview, administrator of La Pesca (LP), 24 January 2013 (FN).

[27] EV, 4 February 2013.

[28] MB, 7 February 2013.

[29] FN, 18 February 2013.

worker in Ampliación Erea explained that the irrigation system would save her many work hours as she now only would have to press a button to irrigate the entire garden instead of moving a hose manually from cantero to cantero.[30]

While the organopónicos were dependent on internationally scaled relations for acquiring the irrigation infrastructure there were two sources for obtaining the actual water. La Pesca, El Vial, and the UBPC had their own wells. In this way the organopónicos were continuously supplied with water through access points scaled within the gardens. In contrast, the irrigation systems constructed in Erea No. 1 and Ampliación Erea would be connected to the city aqueduct.[31] Pumps that ran on electricity from the National Electricity System (SEN) propelled water in this centralised supply system. The water pumps that propelled each organopónico's individual irrigation system also ran on electricity from the SEN.[32] According to a half yearly report, January to June 2010, from the Cuban National Statistics Office (ONE 2010), 58 % of all electricity in the SEN was generated in thermoelectric plants, fuelled by domestic and imported crude oil; 13 % came from combined oil and natural gas generation; and 21 % from distributed generators fuelled by diesel or fuel oil. To power the irrigation systems, the organopónicos were thereby hooked up in larger scaled industrial systems of carbon-intense energy flows.

Integrated pest management and the use of biocides

A critical aspect of the organopónico farming process was to keep the gardens shielded from pests and insects. All the organopónicos used five major methods for pest management. The organopónicos received high points for well-developed integrated pest management systems during the evaluations of the GNAU. Out of 100 evaluation points 35 were related to pest management. These were substrate quality (10 points), 50 % or more canteros intercropped (5 points), control of pests and diseases (10 points), and the existence of barriers and repellent plants (10 points).[33]

Repellent plants, traps, and barriers

Plants and traps that set up certain ecological relations to hinder pest migration physically divided the gardens. This was done in three ways. First, at the ends of each cantero, a set of plants was grown to fend off threatening insects. This included marigold (*marigol* or *flor de muerte*), two kinds of basil (*albahaca blanca* and *albahaca negra*), and Cuban oregano (*orégano francés*), a succulent herb. There were also neem trees (*nim*). Neem leaves and fruits were ground into a powder that produced an effective bio-insecticide when suspended in water.[34] According to a field manual I was provided in El Vial, neem extract works as a repellent, stops digestion, is sterilising, and regulates growth of 160 different species of insect pests.

Second, along with the repellent plants were insect traps. These were made from plastic bottles placed horizontally on a wooden frame where the sides of the bottles had been cut open and the bottles filled with molasses to attract and capture insects.

Third, the organopónicos were physically divided into compartments and were enclosed by brick walls, metal fences, and hedges of banana (*plátano*), maize (*maíz*), millet (*mijo*), and guava (*guayaba*). These acted as barriers between sections of canteros and to the outside to thwart animal, pest, and insect migration.

Burning the soil

Caution was taken as soon as organic material was moved into and within the organopónicos. The administrator of the UBPC described that they always left chicken manure and peat in the compost after it had been brought to the organopónico and before it was used.[35] In this way fungi and nematodes had a harder time to survive from the heat generated from decomposition. The large heap by the gate in Erea No. 1 also served this purpose.

After the harvest, when the canteros were again prepared for cultivation, the soil was formed into a V-shape inside the cantero to expose it to as much sunlight as possible. It was then left for a day so that the sun would burn remaining pests.[36] These spatial-ecological interactions within the organopónicos, between compost, cantero, organic material, and the sun, minimised disease risks.[37]

Polycropping and crop rotation

Furthermore, the organopónicos were polycultures in several dimensions. On an aggregate level, at least ten crops were grown at any one time (for instance in La Pesca) but

30 Interview, worker at Ampliación Erea, 30 January 2013 (FN).

31 AE, 29 January 2013.

32 MB, 22 January 2013; EV, 23 January 2013; LP, 23 January 2013; AE, 29 January 2013; EN, 18 February 2013 (FN).

33 *Metodología…*.

34 AE, 29 January 2013.

35 MB, 25 January 2013.

36 MB, 25 January 2013.

37 In addition, a large section of Ampliación Erea was covered with a black net that provided the canteros with shadow, making it a semi-protected (*semi-protegido*) organopónico.

this could add up to thirty crops. Different crops were usually cultivated in adjacent canteros (ex. chard, beetroot, lettuce, spinach, lettuce, strawberries, etc.)[38] or with one crop in a cluster of canteros adjacent to another cluster or several single-crop canteros (ex. cress, lettuce, lettuce, lettuce, lettuce, lettuce, carrots, chives). One cantero could be divided into adjoining sections with two or more cultigens in the same bed (ex. beetroot, lettuce, and carrots); and, canteros were often intercropped (*intercalados*) meaning that one or more cultigens were sown between the rows of the dominant crop (ex. lettuce intercropped with chives). According to the guidelines from the GNAU, 50 % of all canteros had to be intercropped.[39]

Polycropping also took place in the temporal dimension through crop rotation. When crops were rotated, as well as intercropped, they utilised different nutrients in the soil. The organic material in one cantero could therefore be used during several rotations without being impoverished. Crops with growth cycles of varying length generally followed each other (ex. radish following string beans) and the administrator of the UBPC explained that one should try not to plant two crops that belong to the same family in sequence.[40] Genetic similarity among crops sown in sequence made them more vulnerable to disease. The workers also tried to take advantage of certain crop associations. For instance, cabbage (*col*) would be grown after carrots (*zanahoria*) as carrots minimised the disease risk for cabbage.[41]

The agroecological logic behind this was that "diversity is the enemy of epidemics. … Any agricultural practice that increases diversity over time and space, such as crop rotation or mixed cropping on a farm or in a region, acts as a barrier to the spread of epidemics" (Scott 1998, p. 269). If a farm consists of one single species, in contrast, where all individuals incidentally also are genetically identical from genetic modification, an insect can happily see the entire farm as its dinner table. A diverse farm is more resilient to pest outbreaks as different crops act as barriers for pathogens to spread and thereby spatially limit their habitats. Some crops may also be more resistant to drought while others can manage in overly wet conditions, which makes the diverse farm more resilient to climatic stress.

In sum, the use of repellent plants, plant barriers, grease traps, burning of the soil, and the practices of polycropping and crop rotation were activities where the organopónico workers mediated certain ecological processes to control pests and insects. These practices were all scaled within the organopónico as a spatial unit. Repellent plants and traps constituted predator–prey interactions that worked as physical barriers along with banana and maize hedges. Interaction between organic material and sunlight in various places inside the organopónico reduced the risk for surviving pests. Polycropping set up specific ecological relations between the canteros (different adjacent crops); within the canteros (adjoining crop sections); and even between sown rows (intercropping). Crop rotation similarly encouraged certain ecological relations temporally.

Biocides

In addition, two methods of pest control were used where the organopónicos were scaled in relations that extended outside the garden enclosures. Early during the Special Period over 200 biopesticide production centres called Centres for the Reproduction of Entomophages and Entomopathogens (CREEs) were established across Cuba (Funes 2002, p. 16–17). These centres produce organisms that feed on insects (entomophages) or cause diseases in insects (entomopathogens). Cuban farmers, in all agricultural sectors, could buy these fungi, plants, and insects and use them to control attacks by inserting a natural predator to prey on insects or microorganisms threatening crops. In this way a negative feedback mechanism was mimicked in the agroecosystem by human intervention.

There were two CREEs in Pinar del Río, one north and one south of town. The most commonly used product in all the organopónicos was Trichoderma, an antagonist fungus attacking soil-borne pathogens. El Vial, Ampliación Erea, and Erea No. 1 also used different strains of *Bacillus thuringiensis* and *Beauveria bassiana*, as well as Tabaquina. Tabaquina was a nicotine rich by-product from the cigar industry, which has its geographical centre in Pinar del Río province.[42] Finally, two products were used against snails, at least in El Vial, called Caracolé and Bavotró.[43]

Synthetic pesticides and *Sanidad Vegetal*

In the event that a severe disease invaded an organopónico and spread in a crop, the use of synthetic countermeasures could be authorised by a branch of the Granja Urbana called *Sanidad Vegetal* (Plant Health). Towards the end of my fieldwork, the tomatoes in El Vial had attracted such a severe disease. As tomatoes sold for high prices at the moment, the workers had planted a large section with the same crop. The administrator then brought the issue to a meeting in the Granja Urbana to be authorised to apply a

[38] This and the following examples are from Erea No. 1 on 18 February 2013.

[39] *Metodología…*.

[40] MB, 25 January 2013.

[41] EV, 23 January 2013.

[42] AE, 29 January 2013; EV, 4 February 2013.

[43] I am uncertain of the spelling of these brand names.

synthetic pesticide.[44] I was not able to establish the scalar configuration of the manufacture and distribution of these pesticides, but their content unavoidably made them dependent on petro-industrial energy systems.

Labour power

Another critical energy source for organopónico production was the work done by human labour. UBPC Micro-Brigadas employed 10 people; El Vial, 34; La Pesca, 4; Ampliación Erea, 5; and Erea No. 1, 10. This meant that there on average were 262.5 square metres of cantero per worker and that each worker annually produced slightly more than half a tonne vegetables if the production plan was kept.[45]

Scott (1998) argues, in a discussion contrasting industrial and peasant agriculture, that peasant farming often is seen as economically inefficient in comparison to industrial agriculture due to its labour intensity:

> Organic farmers have occasionally opted for mixed cropping as a way of avoiding the heavy use of fertilizers and insecticides. The most common obstacle to certain (not all) forms of polyculture is that they are too labor intensive in a context where labor is the scarce factor of production. It is hard to know how much of this labor intensiveness is the result of the fact that virtually all machine implements have been designed with monoculture exclusively in mind (p. 418 note 48).

In contrast, it has many times been pointed out in the debate on Cuban urban agriculture that the labour intensive polycultures were an important source of employment during the Special Period. Levins (2005, p. 22), who explicitly writes from a pro-Cuban standpoint, argues that urban agriculture "provides employment for some 300,000 people at a time when capital is not available to invest in more industrial employment. … In the context of the unemployment that appeared with the Special Period, it is socially efficient."

What is "efficient" in terms of labour power input may here also be a contradiction in terms of economic efficiency and energy efficiency. The technologies that are available to work monocultures, which Scott points to, all depend on socioecological scalar formations with global reach that consume fossil fuels. The human labour power that does work in Pinar del Río's organopónicos is considerably more localised and consumes less energy to do work. Labour power is therefore thermodynamically more efficient but economically inefficient in light of currently available technology to do the same amount of work.

Moreover, agroecologists often argue that farming should be a community undertaking implying that labour power should be supplied as close as possible to the farm (e.g. Morgan et al. 2006). Some of the workers in the organopónicos in Pinar del Río lived in the community that the gardens served with vegetables. Others commuted from other parts of the city or even from out of town.[46] Thus, labour supply entered the organopónicos on a larger scale than the nearest community.

Furthermore, the workers themselves tied into the urban food supply system to be able to work. In the UBPC, the cooperative was allowed to collectively purchase foodstuffs with state subsidies for consumption in the organopónico. Vegetables were supplied from the canteros whereas rice, beans, and animal protein were acquired in state shops.[47] For the organopónicos arrendados, on the other hand, the situation was different as they were not allowed to set up contracts themselves:

> Lunch we have to get elsewhere. … We have to buy for high prices. Rice, beans – fundamental things – eggs. When we are at the Granja Urbana we can eat there because they also have a canteen. These are things that UBPCs can solve, they have an assignation of rice and beans and eggs.[48]

Energy to sustain the labour power of workers was thereby essentially external to the organopónicos.

Supplying the city with food

If we now move to the other end of the production chain, there were five possible outcomes for the harvest. All the organopónicos had two major options for marketing their produce, which placed them in relation to the surrounding city. The organopónicos arrendados partly had to sell produce to *centros esenciales* (essential institutions). For example, El Vial delivered vegetables to a hospital, a home for the elderly, two day-care centres, a cantonment of the Revolutionary Armed Forces, to the Ministry of the Interior, and to more than eight canteens of state companies. These relations were all reconciled through the Granja Urbana.[49] The UBPC, in contrast, could sell to whomever they wanted.[50]

44 EV, 4 February 2013; EV, 5 February 2013 (FN).

45 Cantero areas: UBPC Micro-Brigadas, 2705 m^2; El Vial, 10,330 m^2; La Pesca, 600 m^2; Ampliación Erea, 900 m^2; and Erea No. 1, 2000 m^2.

46 MB, 22 January 2013; EV, 23 January 2013; AE, 29 January 2013.

47 MB, 25 January 2013.

48 EV, 23 January 2013.

49 EV, 4 January 2013; FN, 11 February 2013; map from participatory mapping exercise in EV, 22 February 2013.

50 AE, 29 January 2013.

The other option was to sell on the urban vegetable market. This generated higher incomes. All organopónicos had their own vending stalls adjacent to the gardens. The UBPC also had fixed stalls in two agricultural markets (*Las Placitas*) in the city. Beside this they had a mobile outlet and set up vending stalls during city festivals, such as the annual agricultural festival held at city's *Plaza de la Revolución* (Revolution Square). El Vial, in comparison, had five outlets displaced from the organopónico: three in Las Placitas and two ambulating vendors. These were all located in Pinar del Río's city centre and produce was transported either by horse cart or bike.[51]

The other three possible outcomes were for the harvest to end up as gratuities (*gratuidades*), which meant that the vegetables were gifted "to workers or to the Granja or to an agricultural event, or whatever." They could also be counted as a loss as they did not sell (a *merma*). Low quality produce could be pickled in vinegar to be sold in a bottle before being counted as a merma. And if "things didn't go as planned, you had a pest or something", the lost produce would be referred to as a *pérdida*. The aggregated weight of these five outcomes referred back to the annual plan set by the GNAU.[52] The harvest, in any case, connected the organopónicos to other places within the city or to the organopónicos' composts.

The geography of a low-carbon ecology

In sum, organic materials, seeds, water, electricity, pest management, and labour power all contributed to the organopónicos' metabolism (see Fig. 1). The spatial relations between the organopónicos and these metabolic sources, together with the supply of produce to the city, constituted the ecological geography of Pinar del Río's urban agriculture. In the production process, several of these relations were internalised in the organopónicos complying with agroecological ideals of organising a locally autonomous farm. Compost, earthworm humus, some seed production, as well as the use of repellent plants, grease traps and barriers, burning of the soil, polycropping and crop rotation set up spatial relations within the organopónicos. Other relations existed on an urban scale where labour power, biocides from the CREEs, and water were supplied from within the city.[53] Other relations were scaled out of the city where the organopónicos relied on places in neighbouring municipalities to sustain production with chicken manure, peat, livestock manures, sawdust, and limestone. These municipalities all belonged to Pinar del Río province and the case of cachaza shows that the organopónico workers avoided reliance on spatial relations that extended out of the province.

Up to this point, it can be concluded that the organopónicos depended on material flows that were scaled within Pinar del Río province. The organopónico workers' major reason for not relying on relations that extended outside the province was that their sustenance depended on transports that consumed expensive diesel or petrol. These fuels were imported through internationally scaled relations.

However, certain ecological relations adhered to what agroecologists would call an industrial system. Electricity depended on international oil trade; synthetic pesticides were in some cases used in the organopónicos; and tools and capital goods were supplied through international projects. These relations were all mediated on a national scale through the Cuban planned economy. Hence, the urban agricultural system was not self-sustaining in strict accordance with agroecological theory.

Even so, it seems fundamental to Cuban urban agriculture in context of the Special Period that agroecological practices were internalised in the organopónicos. They relied on less carbon-intense resources with significantly narrower spatial reach. The energy throughput in vegetable production from fossilised energy sources was thereby reduced compared to the system under Soviet dependency. But just as in fully industrialised systems, production in part functioned due to diesel, machines, and centralised systems of water and electricity distribution. The organopónicos were not self-contained places in terms of ecosystem functioning.

According to agroecological theory a well-managed agroecosystem should be in ecological equilibrium and maintain itself within the spatial unit of production. The stability of the agroecosystems in Pinar del Río's organopónicos, in contrast, depended on a geography that linked them to multiple places beyond their bounds. The frame of reference could of course be increased to argue that Pinar del Río province constituted a functional agroecological system. But the organopónicos did not return biomass or energy to the places that sustained them. For instance, peat is a non-renewable energy source and the chickens that supplied manure did not feed on organopónico produce. To keep continuously productive, supplying food and income, the organopónicos therefore maintained non-equilibrium ecosystems that kept their internal coherence through social mediation as nutrients, seeds, and water were supplied in the canteros.

To explain this multiplicity of ecological relations that sustained the organopónicos, the theoretical distinction

[51] Maps from participatory mapping exercises in MB, 8 February 2013, and EV, 22 February 2013.

[52] MB, 20 February 2013.

[53] It is of course questionable whether water and biocides are supplied from within the city only because wells and reproduction centres are located there.

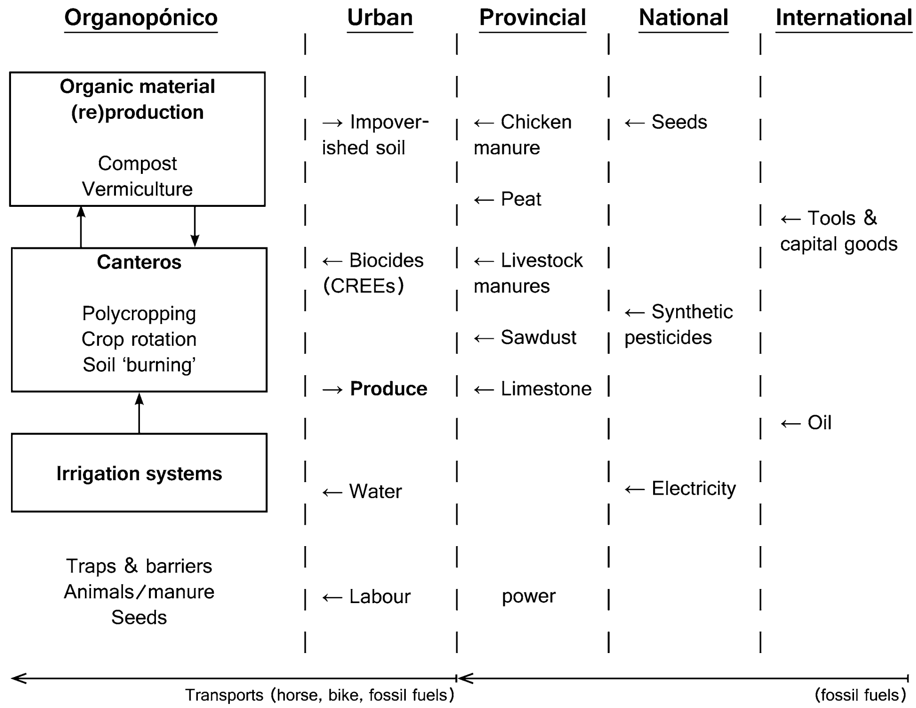

Fig. 1 The ecological geography of organopónico production in Pinar del Río

between an agroecological and an industrial mode of production appears too coarse. The geography of urban agriculture in Cuba neither fits the agroecological model, although some aspects of production undoubtedly were agroecological, nor the industrial model. Instead it embodies traits from both schemes. Organopónico production was simultaneously agroecological (e.g. through intercropping), organic-industrial (e.g. using biocides), and petro-industrial (e.g. through irrigation). Instead, the organopónicos are understood with higher precision through a dialectical conceptualisation of production—as part of an ecological geography, organised into a coherent production system across scales through social mediation. Each farm then necessarily co-constitutes a specific spatial formation. This formation can easily be compared to the agroecological ideal of constructing an internalised, self-sustaining production system without falling prey to inflexible theorisation.

Conclusion

In conclusion, this article stages a meeting between the geographical perspective emerging from low-carbon energy transition studies and agroecological and degrowth perspectives on Cuban urban agriculture. By approaching the organopónicos dialectically, using the concept of scale, I have charted how energy flows and ecological processes are geographically organised to enable urban vegetable production in Pinar del Río. This shows, first, that although the organopónicos have contributed to a reduction of fossilised energy throughput in the urban food supply system, they only in part represent agroecological production. Second, the coarse conceptual distinction between an agroecological and an industrial mode of production poorly reflects the production process in the organopónicos. Instead, the organopónicos are better understood on a continuum between these two ideal types. To resolve this contradiction, I have argued that the system is better understood by means of its geographical configuration. This implies that the urban farms are approached dialectically, where the socioecological relations that sustain production, and that production sustains, are conceptualised as multiscalar configurations that constitute productive agricultural systems. An agroecological system, then, is an ideal type where all socioecological relations are scaled within the farm as a spatial unit.

This geographical perspective not only allows higher analytical precision, but provides an effective political strategy for degrowth. Relative to the food procurement system under Soviet dependency, a degrown, lower-carbon system has been constructed in Cuba by enabling vegetable production in the cities. And whereas the distinction between agroecology and industrial agriculture may be rhetorically attractive, it is not necessarily counterproductive that a theory of agricultural production must be more accommodating than to outline two distinct modes. The vital question is how to construct agricultural systems that are thermodynamically efficient and that keep as much as possible of the input carbon inside vegetables and soils—without displacing additional environmental costs. The concept of scale here offers both an analytical tool *and* a strategy to promote such systems: a further promotion of agroecological scalar practices only seems to make the degrowth case stronger.

Finally, I have exclusively engaged with the theoretical approach that dominates explanations of Cuban urban agriculture in this article. However, in addition to more nuanced agroecological theory, further engagements with Cuban urban agriculture are needed. For instance, studies of animal welfare and of the organic sourcing of seeds and plantlets are highly needed. The discussion on Cuban urban agriculture as a model case of degrowth would also benefit from a substantial quantitative study. In this article I have approached the low-carbon concept in relative terms, as a minimisation of the use of fossilised energy sources throughout the geography of the production process. I have therefore defined low-carbon in relation to the system under Soviet dependency. To understand the re-scaling of the food system better, a quantitative study of organopónico production would provide increased precision. These studies would contribute to a better understanding of the geographical implications of low-carbon systems and, indeed, spatial strategies for degrowth.

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