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Urban Ecology

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A Cuban Agricultural Revolution

How a socialist opposition of the United States lost all imports

Towards the end of the 20th century, a small country south of Florida became the poster child for sustainability. More specifically, Cuba and its leader, Fidel Castro, became famous for their urban agricultural strategies and methods that turned Cuba from a collapsing economy with little to no sources of trade into a relatively prosperous, self-sufficient country. During the rule of the Soviet Union, Cuba largely relied on trade and imports from the USSR (Altieri et al. 1999). But when the Eastern bloc collapsed in 1989, Cuba lost a large portion of its imports. So, in search of a solution, Cuba turned to the US, asking for new trade deals that would save Cuba's economy. But, due to Cuba's political alignment, the United States ultimately denied the deal. In 1991, Robert Torricelli, a Democrat from New Jersey proposed a bill, later known as the Cuban Democracy Act or the Torricelli Bill, striving to cut off the trade between Cuba and the United States (LeoGrande 1998). The purpose of this bill, in the words of Torricelli himself, was to "wreak havoc on the island" (PBS 2022). After being passed by Congress in 1992, virtually all trade from the United States to Cuba was cut off, as well as travel between the two countries, and families could no longer send money to their friends and family in Cuba (PBS 2022). The premise of the bill stated that the United States would not reverse this bill until Cuba began democratically electing their leaders. In other words, this bill was a political ploy to try to force Cuba into a capitalist democracy after the fall of the Soviet Union (LeoGrande 1998). In response to the lack of a source of trade, Cuba and Fidel Castro turned inward, searching for ways in which Cuba could support itself. Among the variety of ways to more sustainably function as a society, urban agriculture became prominent.

How exactly did Fidel Castro create a greener Cuba, with the implementation of urban agriculture? It was not carried out necessarily by desire but rather by need. The country was tasked with facing challenges in using urban spaces for agriculture, such as little land available and poor nutrient content in urban soils. However, strategies, such as organoponico, a farming technique that maximizes water and land availability, two significant problems with urban agriculture in areas with suffering economies, provided Cuba with the chance to get back on its feet. Although after some time the successes from the variety of strategies became apparent, it was not a utopia; there were some failures that, to this day, Cuba continues to deal with. The prolonged effects of this agricultural revolution in Cuba are striking. But, was all of this fortuitous? Or could it be repeated? Can Cuba's sustainable practices and implementation of them be a model for other countries to follow? Or was it simply happenstance?

The trials and tribulations of metropolitan farming

The implementation of urban agriculture comes with a lot of challenges, especially when the urban area is already urban. Some of these difficulties have to do with the infrastructure. In the case of Cuba, much of the urban agriculture implementation is centered around the country's capital, Havana. For instance, the water pipes and pumps in the city were very old by the 1990s (Altieri et al. 1999). Failure to transport water to the various garden sites throughout the city could have led to widespread crop failure and a loss of a central food source for the city. Furthermore, the quality of water pipes and pumps does not matter when there is no water to pump and transport. From November to April, Cuba experiences its dry season (Altieri et al. 1999).

Meanwhile, without land, there is no use for water. In a city, such as Havana, which was blossoming in the late 21st century, land was very limited (Altieri et al. 1999). And of the land available, even less of it was arable (Garcia-Sarraff et al. 2013). Most of it had little to no soil and low organic matter content (Garcia-Sarraff et al. 2013). Being in an urban area, the land was also often littered with anthropogenic litter such as "garbage, glass, rubble, and shards of concrete and other building materials" (Altieri et al. 1999). Wortman and Lovell (2013) describes how American urban agriculture would be difficult in many metropolitan areas throughout the country due to soil contamination of heavy metals, such as lead (Pb), from anthropogenic sources including gas and house paint. Although these heavy metals have since been removed from these common substances found in urban areas over 30 years ago, the contaminants themselves and their effects persist, especially in municipal soils.

Urban agriculture production was no easy task in a city ridden with air pollution, a suffering economy, and limited access to fertilizers and pesticides. Air pollution in cities across the world, such as Havana, has the potential to cause health risks in fresh produce; some vegetables from urban agricultural sites have been found with high concentrations of heavy metals (Tuijl et al. 2018). In the 90s, Castro also had to invest large amounts of resources to convert Havana into an urban agriculture site. Operational costs in the socialist country were also put largely on the government (Tuijl et al. 2018). Some of these costs include paying for infrastructure, energy expenditures, and management salaries (Tuijl et al. 2018). Additionally, due to low imports of pesticides and herbicides from the USSR, Cuba was forced to search for new versions of these substances that they could create on their own (Zunes 2016). This led to an increase in the production of natural organic fertilizers (Garcia-Sarraff et al. 2013). But, this also became a challenge for Castro as resources were low throughout the country.

Strategies: how Castro's ideas found success

Coming out of an era in which Cuba could rely on the Soviet Union and its allies for imports, including pesticides and herbicides, Cuba was forced to look inward to cultivate its urban gardens without pests. For example, they began implementing wasps, nematodes, fungi, and ants for pest control (Zunes 2016). Wasps, for instance, are parasites that "feed on and kill their hosts", which are often scales and whiteflies. These hosts are known to extract the juices out of a plant, ultimately slowly killing the plant (Barrett 2010). Furthermore, nematodes and fungi are two kinds of pathogens that feed on plant and leaf-eating invertebrates such as aphids, caterpillars, and mites. Meanwhile, although ants can have negative, pest-like effects on some plants, they can also reduce the number of pests and thus the amount of damage they cause as they are generalist consumers, often feeding on other arthropods (Anjos et al. 2022). These strategies helped clean up the produce that they were making; consumers were no longer ingesting residues of toxic pesticides. This practical change in farming also improved the health of the farmers and workers themselves (Zunes 2016). Previously they had been working with so many of these insecticides that they were being overexposed and experiencing detrimental effects.

Furthermore, in Cuba, the agricultural revolution nearly ended the monoculture model, a farming method in which one piece of land is used to cultivate one crop and one crop only, describes Zunes (2016). Instead, they not only grew a larger variety of crops but also an increased total number of crops. Implemented strategies such as crop rotation, intercropping and soil conservation deserve much of the credit for converting and improving the once monoculture model into a polyculture model in Cuba. According to Wikifarmer (2022), crop rotation creates an environment in which one crop is never grown in consecutive growing seasons. In carrying out this method, farmers see a decrease in soil erosion, an improvement in soil structure, an increase in soil nutrients and biodiversity, and a reduction in weed and pest populations. Yu et al. (2022) describes how crop rotation improves water dynamics and biological conditions in plant systems. Other studies mentioned in this paper found that due to the increase in plant diversity by crop rotation, herbivores, weeds, and pathogens are not able to as effectively and consistently negatively affect crops. Meanwhile, intercropping is the "practice of growing two or more crops in proximity" (Natural Water Retention Measures 2013). This allows plots of land to produce greater yields by increasing soil water retention, preserving biodiversity, and better filtering pollutants. Ouma and Jeruto (2010) discusses various intercropping methods, such as row intercropping, strip intercropping, mixed cropping, and relay intercropping. Row intercropping is where at least two crops are grown together with one or more of the crops planted in rows. Farmers who use the strip intercropping method grow at least two crops far enough apart to allow for machine harvesting, but close enough to positively affect each other. Mixed cropping is where at least two crops are grown in the same plot in an almost random way; there is no clear-cut row configuration. Finally, farmers carry out relay intercropping by planting a second crop while the first crop is in its reproductive stage but before the harvest stage. These four intercropping techniques can all contribute to improved agricultural outcomes such as increased crop productivity, efficient use of labor, and erosion control (Ouma and Jeruto 2010). The same study found that intercropping often provides shade for the soil, ultimately decreasing its average temperature. This prevents the phenomenon where organic matter essentially burns, removing the beneficial nutrients it has for the soil. Typically, the monoculture method rapidly depletes soil nutrients in just a few years or harvests. By exchanging the polyculture model for the monoculture model, Castro was improving the level of production and the health of the soil.

Another effect of the collapse of the Eastern bloc was a severe drop in fuel imports for Cuba (Zunes 2016). So, to ensure a sufficient supply of energy, Castro began to implement renewable energy infrastructure. Some of these included windmills, solar, biomass generators, hydroelectric power, solar ovens in rural areas, and using sugarcane waste to power sugar mills (Zunes 2016). Although many of these sustainable energy sources were not implemented in urban areas, they helped power urban centers as well as urban agriculture. Urban agriculture requires infrastructure, such as elevated garden beds, specific irrigation systems, and people and tools to harvest the produce. All of these require energy, in one form or another, to build or function.

Beyond the renewable energy sources, reforestation was carried out as well in hopes of increasing Cuba's biodiversity and furthering biomedical research. Zunes (2016) describes how this allowed for an improved hunt for discovering new medicines, such as antibiotics. The country even created a biotech center in the forest dedicated to these causes. This change in Cuba's forests has led to a return to the use of more traditional, natural medicine from plants in the forests (Zunes 2016). In this attempt to reforest deforested land, Cuba strived to emphasize the replanting of native species, overall increasing the biodiversity and strengthening Cuba's forest (Zunes 2016). From the 1959 revolution until 2016, the number of woodlands or forests has grown more than twice in size (Zunes 2016).

The recycling of waste was heavily stressed as well. In a variety of ways, Havana began to use the waste of plants, animals, and factories (Altieri et al. 1999). As mentioned previously, soil in urban areas was often poor in nutrients. So by recycling waste, urban gardens were able to use much of the nutrient-rich organic matter from waste to fertilize soils. This allowed for increased self-sufficiency. Instead of looking outward for soils or fertilizers, the Cuban government realized the country was already creating all the soil, or organic waste, that it needed.

To come up with and carry out all these different strategies to make Cuba a more self-sufficient country, the knowledge of the community was utilized (Altieri et al. 1999). At the time, Cuba was split when it came to agricultural awareness. In rural areas, there were a lot of well-educated farmers. Meanwhile, in the cities, many people did not have anything to do with agriculture and thus knew nothing about it. So, to carry out the goal of urban agriculture, the country had to utilize the already existing knowledge on agriculture and push to increase the spread of this knowledge throughout urban areas, where farming would soon become very prevalent. The formation of clubs and organizations helped catalyze this sharing of knowledge so that communal farms in cities could function at high levels (Altieri et al. 1999).

A pre-existing predicament in the country was that low-income areas had a hard time accessing healthy foods (Altieri et al. 1999). Therefore, by putting small farms within urban, often poorer areas, the need for transportation was discarded. This allowed for increased access to healthier foods for impoverished communities in urban areas.

The urbanization of agriculture and its various triumphs

A variety of these complex, yet successful strategies were due to one overarching style of agriculture that Cuba implemented: Urban Agriculture. Yes, the urbanization of agriculture allowed for benefits such as less transportation needed. However, the implementation of organoponics and a supportive, decentralized government system truly enabled urban agriculture to excel ("Organoponic…").

Organoponics, or *organoponico*, is a farming technique frequently used in cities. At the most basic, it is farming in elevated plant beds using a mix of soil and compost. Oftentimes, drip irrigation is implemented as well. The article "Organoponic…" describes it as a "system that uses an organic substrate, obtained from crop residues, household wastes, and animal manure, from other intensive, high-yielding horticulture production systems." Typical organoponic systems often use very small amounts of water to *carry* nutrients to the roots of plants (Simões et al. 2010). Therefore, as opposed to hydroponic systems or traditional agriculture systems with conventional irrigation (ie. sprinkling), organoponics are much more water-efficient. Furthermore, over time, the soil quality improves as more and more organic matter, recycled from community departments, is added to the soil. Additionally, due to the various elevated gardens, each garden bed can have soil specifically tailored toward the desired crop. And, if the soil becomes infected with harmful fungi or nematodes, it can be replaced. The article "Organoponic…" presents how in a worst-case scenario, garden boxes can also be disassembled and relocated. Paired with these practices are drip irrigation, mixed cropping, crop rotation, and integrated pest management. These techniques allow for minimal water and land use as well as high production. The same source notes that organoponics works very well in urban areas because it can be implemented on building sites, vacant lots, and roadsides. Additionally, farmers would get training on how to analyze and then get rid of or reduce problems with production. For example, if there was a fungal problem, instead of attacking and trying to cure the symptoms, they were taught that improving drainage could eliminate the detrimental fungus ("Organoponic…").

How the Cuban government worked with the implementation of these techniques is also partially responsible for the success. For example, the government dedicated country-wide resources to the manufacturing of natural fertilizers, natural pesticides, seeds, and food for animals ("Organoponic…"). The government also strived to understand where there was food demand and introduce, create, and fund urban gardens in those areas. They aimed to sell produce at low prices for public services, which are paid for by taxes in the US, such as schools, and hospitals. Castro also emphasized the importance of protecting crops. The same study noted that Cubans promoted the communal production of compost, green fertilizers, vermicompost, bio-fertilizers, and liquid fertilizers. The connection of farmers to their sources of organic wastes for fertilizers was also thanks to the Cuban government, as well as the efforts to locally produce seeds ("Organoponic…"). Instead of importing seeds from elsewhere, Cuba began having civic farms rescue and replant seeds to produce more of themselves. This cycle led to a surge in seed availability across the country, making it more simple for urban gardens and farms to obtain seeds to grow crops. The amount of power the government had in carrying out these strategies worked so efficiently that Cuba was being asked for help from various other countries.

Due to these government-run intensive gardens, there was a 17-fold increase in production from 1.5 to 25.8 (kg/m^2) from the year 1994 to 2001 (Koont 2009). This was largely due to the ability to produce fruits and veggies year-round. Urban agriculture and organoponics allowed for yields of up to 20 kg/m^2 ("Organoponic…").

A success story; not only in production but also in national economy

The various sustainable agricultural strategies implemented ultimately led to healthier Cubans (Zunes 2016). This was because the agricultural revolution allowed for an uptick in the consumption of organic vegetables and a reduction in that of red meat. Additionally, farmers were healthier, too, as pesticides and herbicides suddenly became natural as opposed to the synthetic, sometimes toxic substances used prior. Cubans were also living in prettier, more scenic areas as dumps and vacant lots became beautiful micro-ecosystems (Altieri et al. 1999).

At the same time, Cuba saw a massive increase in urban agriculture education, available jobs, and economic success with the implementation of a decentralized government. An urban agriculture program was created by the government to ensure focus and attention to this important sector of production (Koont 2009). Within the program, there were 28 subprograms with concentrations in crops, technical education, organic manures, marketing, etc. As each of these subprograms had its own leader, the Cuban government was decentralized ("Organoponic…"). Instead of the government taking control and overseeing all aspects of urban agriculture, they gave power to those who were educated and specialized in each subprogram. These subprograms allowed for the creation and opening of 350,000 new jobs for Cuban residents. This was critical for Castro's suffering economy and allowed the country to begin to thrive in the aftermath of the Eastern bloc's collapse.

A double-edged sword

Despite the various positive outcomes of this revolution in Cuba, there were some failures. Fruits and vegetables are widely known to be healthy, and thus necessary parts of the average person's diet. However, the production of produce by urban agriculture turned out to be less healthy than ideal (Tuijl et al. 2018). Organic fertilizers and substrates can be contaminated with pollutants such as cadmium, lead, arsenic, selenium, mercury, nickel, and chromium (Alfaro et al. 2017). The effects of some of these pollutants include a reduction in crop productivity by toxicity to plants and toxins entering the food chain through plant intake, skin absorption, or dust inhalation (Alfaro et al. 2017). The same study found leaching of these contaminants from soils into water sources. This strictly goes against the argument that the alternative, more natural versions of these farming substances lead to healthier farmers and consumers. In this study, they also hypothesized that based on the raw materials used for compost, hazardous chemicals from solid wastes from anthropogenic sources may infiltrate crops produced in urban areas (Alfaro et al. 2017). Some composts that used metropolitan waste had contamination from some toxins. The article states that elements, such as cadmium, lead, mercury, arsenic, selenium, and nickel, were found at several times higher than legal levels. Data ranged from double the level allowed in mercury and selenium to seven times the level allowed in lead (Alfaro et al. 2017). This is because the compost used for these crops came from sources that were contaminated with human waste. On the contrary, the study found that when compost is used from sources such as animal manure, filter cake, and organic matter from decaying crops, especially that broken down by earthworms, trace-element contamination remains in the permissible ranges (Alfaro et al. 2017). Therefore, urban agriculture can be a safe, very productive agricultural system if the substances used come from reliable, tolerable sources.

The various use of pesticides and herbicides paired with intense, high-yield agriculture has also slowly damaged the land. Although organoponics was implemented in various metropolitan centers throughout Cuba, some more rural regions of Cuba continued with traditional farming practices. In Palma et al. (2015), research presented from another study, Iglesias et al. (2000), found that of Cuba's 6.7 million hectares of existing agricultural land in 2013, 14% of it was impacted by salinization, high salt content, and sodicity, excessive amounts of sodium which can decrease soil productivity (Science Direct 2022). Furthermore, Palma et al. (2015) goes on to state that 29% of the previously mentioned land has been affected by erosion, while large parts of the land were also found to have limited drainage and low fertility. Over half of this land also does not contain enough organic matter. Despite these statistics being published more recently, they may not be entirely caused by urban agriculture and Cuba's green revolution. Instead, these figures could have been caused by agricultural practices before the collapse of the Soviet Union.

<u>A spread of success</u>

In the wake of Cuba's Green Revolution, the country has been hoisted onto the "world stage as a global leader in sustainable agriculture" (Fernandez et al. 2018). Cuba has shown the various potential benefits that come from the implementation of urban agriculture and other sustainable practices. Furthermore, Cuba continued with their sustainable agriculture practices despite imports eventually becoming available again. For example, when Venezuela became a new source of cheap oil, Cuba denied the offer, choosing to retain its sustainable innovations (Zunes 2016). The same situation occurred when Cuba was offered imports of artificial, chemical herbicides and pesticides, denying them because they had alternative, more sustainable substances that discarded the negative impacts on farmers, consumers, and soils.

Cuba's actions also sparked a surge of research in this sustainable farming field. Pearson et al. (2010) argues that it is necessary to pinpoint the fundamental aspects of this field to help policymakers and urban developers/designers create resilient cities. A specific case of this would be implementing food industries with available jobs in areas susceptible to flood (Pearson et al. 2010). Furthermore, Person et al. goes on to describe how experimenting with innovations is important as doing so would foster the hunt for future ideas as well as give researchers an avenue to test their novel plans. For example, varying taxes on land to encourage sustainable urban agriculture or stipends for urban farms that act as carbon sinks, contributing to carbon sequestration.

Cuba's agricultural success story quickly made its way to the United States. Despite having poor trade relations due to Cuba's socialist background as well as previously being backed by an adversary of the US, the Soviet Union, scientists and sustainability activists throughout the United States have pushed for more sharing of information and knowledge on urban agriculture. This is largely because there is simply not enough knowledge regarding urban agriculture. Therefore, the United States is slowly being internally pushed towards improving relations with Cuba so that the country and its citizens can reap the benefits of urban farming. Many urban agriculture projects in the United States have come from social movements and nonprofit organizations with young, progressive ideas striving for various things, such as urban renewal, sustainability initiatives, education, and more (Wortman and Lovell 2013). After the gradual sharing of information, the United States has begun trying to implement urban agriculture within its borders. However, this has raised a handful of predicaments regarding the quality of soils and water availability. As mentioned previously, Wortman and Lovell (2013) found that many American soils are still contaminated with lead. This contamination comes from gas and house paints that used to be made with heavy metals. Additionally, 87% of freshwater in the United States is consumed by agriculture (Wortman and Lovell 2013). Thus, there is not a significant amount of water ready for a new wave of agriculture. Although urban agriculture does conserve water, upon the implementation of the sustainable strategy, the United States would ultimately be using more water. Lovell (2010) describes how American urban agriculture is being held back by economic desires. On top of the fact that there is already little undeveloped land in urban centers around the US, many land tenants would rather pursue commercial development, for example, on open, urban lands than agriculture because it would likely be more profitable for the landowner. The same study describes how finding land that is capable of producing food, nonetheless available, is very difficult as sunlight availability, soil nutrient richness, and irrigation difficulties can be easy scapegoats for landowners. Unfortunately, these can often lead to empty lots either never being converted into metropolitan farms or prospering development being built on top of them.

Given this, research presented by Wortman and Lovell (2013) shows what the United States must do to be able to realistically continue striving for urban agriculture. For example, the United States must minimize the risk of soil contamination by providing more research-based information and training to urban farmers on the distribution of various contaminants in metropolitan areas as well as the prevention of soil destruction and its habituation (Wortman and Lovell 2013). Further research on spatial patterns of contaminants would also help cities determine where it is best to implement urban gardens. Additionally, more research is needed on implementing high-quality, space-efficient production systems, such as high tunnel production, season extension technology, vertical food production, aquaponic function, and high-value specialty crops (Wortman and Lovell 2013). Along with increased information on how urban microclimate and atmospheric environments influence food production and efficient water use, the implementation of urban agriculture in urban centers around the United States is possible.

Although the United States and Cuba have had poor relations over the years, the first US-Cuba delegation regarding agriculture took place in the early 1990s (Fernandez et al. 2018). This has stimulated the slow exchange of knowledge over the years on urban agriculture. For example, there have been various meetings between “farmers, alternative agriculture advocates, policymakers, and academics… regarding agroecology, food sovereignty, food security, climate change, etc” (Fernandez et al. 2018). Furthermore, as international relations have improved, universities from both countries have begun collaborating to allow students to learn from Cuba’s agricultural successes. Some of these universities include the University of Florida, the University of Havana, the American University, the University of Vermont, the Research Initiative for the Sustainable Development of Cuba, and the National Cooperative Business Alliance’s US-Cuba Working Group (Fernandez et al. 2018).

Conclusion

Through its own green revolution, Cuba became a self-sufficient country. With the use of urban agriculture, Cuba suddenly became an icon in the world of sustainability. However, it seems Cuba’s agricultural revolution may have occurred by chance, rather than by design. Had Cuba not been isolated – both geographically and economically – Cuba may not have become so sustainable. Furthermore, the largest reason for Cuba’s switch to urban agriculture was due to the crash of the Soviet Union. This, along with the fact that Cuba was once backed by the Communist bloc, cut off nearly all of its trade imports from other Soviet-allied countries and the United States. Additionally, the country is an island in the middle of the Caribbean Sea. This tropical region of the world, widely known for its biodiversity, also likely played a role in the success of Cuba’s urban agriculture. Had the region was not so warm and humid, Cuba’s revamped farming techniques may not have been so successful. If the same incident happened to a country with less consistent warmth and humidity, such as Iceland, there is a high likelihood that these implemented practices would have been less successful, had they not failed. Nonetheless, Cuban practices can be borrowed and applied throughout the world in hopes of building more sustainable agriculture. Although a country may not be able to become as successful as Cuba in agriculture, countries could still improve their agricultural practices. Other countries could still reap the benefits of less water use, less urban heat island effect, and healthier farmers and citizens. Therefore, countries around the world should strive to implement as many of Cuba's urban agricultural strategies as possible to promote sustainability everywhere.

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