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Food Security, Industrialized Agriculture, and a Changing Global Climate: Perspectives on the United States and Cuba

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FOOD SECURITY, INDUSTRIALIZED AGRICULTURE, AND A CHANGING GLOBAL CLIMATE: PERSPECTIVES ON THE UNITED STATES AND CUBA

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I. INTRODUCTION

Despite the dramatic improvements in food production in the developed world, due at least in part to a system of industrialized agriculture that grew out of the "Green Revolution" of the mid-20th century, food security has been elusive throughout the world. The promise of high production agriculture feeding the world was never realized, and industrialized agriculture brought with it a host of new environmental, health, social, and economic problems that have yet to be solved. Global climate change will only intensify the enormous challenge of achieving global food security, particularly in the poorest and most vulnerable countries.

During the Green Revolution, the United States and Cuba, only ninety miles apart geographically but worlds apart in many other respects,

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developed very different systems of agricultural production. The United States developed a vast system of industrialized agricultural production, focused largely on commodity crops for use in processed foods, animal feed and more recently biofuels, or crops destined for export markets. In contrast, Cuba became an internationally recognized leader in "agroecology"—a type of agriculture antithetical to industrialized agriculture.

The U.S. experience demonstrates that although industrialized agriculture can produce high yields, it brings with it serious human health and environmental problems including widespread water pollution, toxic air pollution, farmworker poisonings and birth defects in children of farmworkers, the global pollinator crisis, loss of biodiversity and ecosystem services, and harm to threatened and endangered species. Equally troubling is that, despite the high economic, social, and environmental costs, industrialized agriculture has not lived up to its promise of providing a secure global food supply. Moreover, industrialized agriculture is a significant contributor to global greenhouse gas emissions, the primary cause of anthropogenic climate change. U.S. agricultural policy has incentivized industrialized agriculture while at the same time, U.S. environmental law has failed to adequately address the serious health and environmental risk of industrialized agricultural practices.

The agroecology approach, which has become ubiquitous in Cuba, treats the farm as a functioning ecosystem, complete with natural pest management through predators and parasites of pests, non-chemical means of developing soil fertility, and a diversity of crops and varieties that builds resilience into the system, without reliance on fossil fuel inputs. Consequently, agroecology does not cause the significant environmental harms of industrialized agriculture and is also better-equipped to adapt to altered conditions, including those resulting from climate change. As Cuba enters a period of significant economic development and as demand for more and better food increases, the nation will be faced with the choice of either adopting the industrialized agriculture approach of most of the developed world, along with its concomitant health and environmental harms; or finding ways to scale-up and further advance its agroecology approach. If Cuba can successfully expand its agroecology approach to achieve food security for its people, and perhaps enter it into the international export market, Cuba could become a global leader in demonstrating how to achieve food security in a low carbon economy. Such an expansion will avoid many of the health and environmental harms historically tied to industrialized agriculture.

This Article outlines the challenges of feeding a growing population in a time of climate change and in the shadow of the risks presented by

industrialized agriculture.[1] Part II presents an overview of current food insecurity and explores the likely exacerbation that will result from the impacts of climate change. Part III compares the evolution of agricultural systems in the United States and Cuba. This part also examines the environmental harms caused by industrialized agriculture in the United States and the limited protection offered by U.S. environmental law to protect against these harms. This part then turns to the evolution of agroecology in Cuba and examines the benefits of the system as they relate to climate change and food security. The Article concludes with a discussion of how Cuba, through its highly developed agroecology, is poised to be a world leader in climate resilient agriculture with a low carbon economy.

II. THE HUMAN RIGHT TO FOOD, FOOD SECURITY, AND FOOD SOVEREIGNTY IN A CHANGING GLOBAL ENVIRONMENT

A. *Food Security and Food Sovereignty*

It goes without saying that, along with air and water, food is the most basic of human needs. Although human survival is possible with only a minimal amount of food, a sufficient amount of food with adequate calories and nutritional value is critical to human health and the ability for humans to earn livelihoods, and function in society.[2] Moreover, a consistent supply of food is critical to ensure food security, which is essential to a stable society.[3]

International agreements dating back to the 1966 International Covenant on Economic, Social and Cultural Rights have long recognized the basic human right to food and have sought to achieve global food security. The U.N. Food and Agriculture Organization (FAO) defines "food security" as a state in which "all people at all times have physical, social, and economic access to sufficient, safe and nutritious food which meets their dietary needs and food preferences for an active and healthy life."[4] Food security consists of four elements: food availability, food accessibility, food utilization, and food systems stability.[5] Cuba

1. Portions of this Article have been adapted from Mary Jane Angelo & Joanna Reilly-Brown, *Whole System Agricultural Certification: Using Lessons Learned from LEED to Build a Resilient Agricultural System to Adapt to Climate Change*, 85 U. COLO. L. REV. 689 (2014).

2. MICHAEL C. LATHAM, HUMAN NUTRITION IN THE DEVELOPING WORLD ch. 1 (1997), *available at* http://www.fao.org/docrep/w0073e/w0073e03.htm [https://perma.cc/5EL3-U2JC].

3. *Id.* at ch. 2.

4. FOOD & AGRIC. ORG. OF THE UNITED NATIONS, TRADE REFORMS AND FOOD SECURITY: CONCEPTUALIZING THE LINKAGES 29 (2003), ftp://ftp.fao.org/docrep/fao/005/y4671e/y4671e00.pdf [https://perma.cc/57QF-WK3S].

5. *Id.* at 25–30.

recognizes the basic human right to food security and has made significant progress toward ending hunger and malnutrition, but much remains to be done.[6]

For decades, the developed world believed that food security could be achieved through a combination of trade of food produced via large-scale industrialized corporate agriculture and increased trade liberalization.[7] Many believe that the quest for food security promoted the "corporate food regime," which ignores adverse effects of dispossession of small producers, the lack of local control over food policy and choices, and the dependence of the developing world on corporate farm production and importation.[8] These concerns led countries to shift from seeking food security to seeking food sovereignty.[9]

Food sovereignty is defined as:

> [T]he right of peoples to healthy and culturally appropriate food produced through ecologically sound and sustainable methods, and their right to define their own food and agriculture systems. It puts the aspirations and needs of those who produce, distribute and consume food at the heart of food systems and policies rather than the demands of markets and corporations. It defends the interests and inclusion of the next generation. It offers a strategy to resist and dismantle the current corporate trade and food regime, and directions for food, farming, pastoral and fisheries systems determined by local producers and users. Food sovereignty prioritises local and national economies and markets and empowers peasant and family farmer-driven agriculture, artisanal fishing, pastoralist-led grazing, and food production, distribution and consumption based on environmental, social and economic sustainability.[10]

Food sovereignty differs from food security in that food sovereignty emphasizes the '"right of nations and peoples to control their own food systems, including their own markets, production modes, food cultures,

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6. FOOD & AGRIC. ORG. OF THE UNITED NATIONS, THE STATE OF FOOD INSECURITY IN THE WORLD 12, 17 (2015), http://www.fao.org/3/a-i4646e.pdf [https://perma.cc/C57B-VRUJ] [hereinafter FOOD INSECURITY]; *see also* CONST. OF THE REPUBLIC OF CUBA 1976 art. 9 (codification 2003); WORLD FOOD PROGRAMME, *Where We Work: Cuba*, https://www.wfp.org/countries/cuba [https://perma.cc/L7BV-K2L3] (last visited Aug. 9, 2017).

7. *See generally* Efe Can Gürcan, *Cuban Agriculture and Food Sovereignty: Beyond Civil-Society-Centric and Globalist Paradigms*, LATIN AM. PERSP., July 2014, at 130 (tracing factors contributing to food sovereignty in Cuba).

8. *Id.* at 142.

9. *Id.* at 142–43.

10. *Declaration of Nyéléni*, NYÉLÉNI.ORG (2007), https://nyeleni.org/spip.php?article290 [https://perma.cc/KBN4-MPUW] (last visited Aug. 9, 2017).

and environments."'[11] The absence of food sovereignty can lead to drastic outcomes including famine, widespread malnutrition, poverty, and violence. The global food crisis that began in late 2007 increased human hunger by an estimated 75 million people and drove another 125 million people into extreme poverty.[12] The crisis increased global food prices by more than 80%, which led to violence in some regions and ultimately brought much-needed attention to the importance of food sovereignty.[13]

B. *Climate Change and Food Security*

Climate change is the most serious environmental issue of our time and will likely have severe impacts on many aspects of society, including the agricultural sector. Expected climate change impacts will likely compromise all four aspects of food security. Nowhere is the connection between climate change and poverty more profound than in the area of food security. A recent study produced by the World Bank predicts that the decreased agricultural productivity and increased food prices caused by climate change could "force more than 100 million people into extreme poverty by 2030."[14] As the globe warms, reduced agricultural production will exacerbate the existing challenges of chronic hunger. Particularly in the developing world, livelihoods will be imperiled due to food resource, natural resource, and food system-related infrastructure, all of which will also be compromised by climate change.[15] Losses to agricultural livelihoods will further contribute to chronic hunger.[16]

Any residual reservations about the crucial need for international action to limit the effects of climate change were dispelled at the December 2015 Intergovernmental Panel on Climate Change (IPCC),

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11. Gürcan, *supra* note 7, at 130 (quoting Hannah Wittman et al., *The Origins and Potential of Food Sovereignty* 1, 2 *in* FOOD SOVEREIGNTY: RECONNECTING FOOD, NATURE, AND COMMUNITY (Annette Desmarais et al. eds., 2010)).

12. *Id.* at 129; *see also* FOOD & AGRIC. ORG. OF THE UNITED NATIONS, THE STATE OF FOOD INSECURITY IN THE WORLD 2008: HIGH FOOD PRICES AND FOOD SECURITY—THREATS AND OPPORTUNITIES 4, 6, 8 (2008), http://www.fao.org/3/a-i0291e.pdf [https://perma.cc/LQL3-XT8S].

13. THE WORLD BANK, *Food Price Surge Could Mean '7 Lost Years' in Poverty Fight, Zoellick Says* (Apr. 11, 2008), http://go.worldbank.org/U8PAI82X20 [https://perma.cc/4JXY-4UV3]; Frederick Reese, *World Bank Report Warns of Increased Rioting as Food Prices Rise*, MINT PRESS NEWS (June 5, 2014, 5:00 AM), http://www.mintpressnews.com/world-bank-report-warns-of-increased-rioting-as-food-prices-rise/191946/ [https://perma.cc/KWC3-PQW8].

14. STEPHANE HALLEGATE ET AL., SHOCK WAVES: MANAGING THE IMPACTS OF CLIMATE CHANGE ON POVERTY xi (2016), https://openknowledge.worldbank.org/bitstream/handle/10986/22787/9781464806735.pdf [https://perma.cc/D6R7-C5JG].

15. William R. Cline, *Global Warming and Agriculture*, FIN. & DEV., March 2008, at 24–25, https://www.imf.org/external/pubs/ft/fandd/2008/03/pdf/cline.pdf [https://perma.cc/6XMM-NC4A].

16. FOOD INSECURITY, *supra* note 6, at 40.

Conference of the Parties (COP21) in Paris.[17] Of the 197 nation state members of the IPCC, 187 of them, representing approximately 95% of all greenhouse gas (GHG) emissions, submitted their "Intended Nationally Determined Contributions," in which they set forth national targets and actions to reduce GHG emissions.[18] Both the United States and Cuba were among these 187 nations.[19]

Among the issues raised at COP21 were concerns about the impacts of climate change on agriculture and food security.[20] Member states especially focused on the fact that the majority of food and agricultural-related repercussions will be borne by the most vulnerable populations in developing countries.[21] In particular, the predicted reductions in food production and increased food prices will increase global poverty and hunger. During the lead-up to the COP21, FAO warned that excluding agriculture from climate change policies would increase the number of hungry people in the world, which would result in mass "climate migration."[22] Climate change policy choices made today could dramatically influence whether future generations will have adequate food and food security.

Despite the unprecedented commitments made in Paris, human rights in general, and concerns with food security and agriculture in particular, played only a minor role in the actual agreement that emerged from COP21, the Paris Agreement (the Agreement). The language of the Agreement makes short shrift of concerns regarding climate change

17. Paris Agreement Under the United Nations Framework Convention on Climate Change, Dec. 12, 2015, T.I.A.S. No. 16-1104 [hereinafter Paris Agreement], *available at* http://unfccc.int/files/essential_background/convention/application/pdf/english_paris_agreement.pdf [https://perma.cc/76H8-ZNNQ].

18. *Nationally Determined Contributions (NDCs)*, UNITED NATIONS FRAMEWORK CONVENTION ON CLIMATE CHANGE, http://unfccc.int/focus/items/10240.php [https://perma.cc/PE43-RE9L] (last visited Sept. 3, 2017).

19. *Comparison of INDCs*, CTR. FOR CLIMATE & ENERGY SOLUTIONS (Dec. 21, 2015), http://www.c2es.org/indc-comparison [https://perma.cc/A5P3-T5FK]; *Cuba Becomes 173rd State to Submit U.N. Climate Plan for COP21*, CLIMATE ACTION PROGRAMME (Nov. 23, 2015), http://www.climateactionprogramme.org/news/cuba_becomes_173rd_state_to_submit_un_climate_plan_for_cop21 [https://perma.cc/H4F6-CKAT].

20. *CCAFS at UN Climate Change Conference COP21*, RESEARCH PROGRAM ON CLIMATE CHANGE, AGRIC. & FOOD SEC. (Dec. 2015), https://ccafs.cgiar.org/ccafs-un-climate-change-conference-cop21#.v5y3sjoaoko [https://perma.cc/4ZR8-LTZZ].

21. *Paris Climate Agreement Unlocks Opportunities for Food and Farming*, RESEARCH PROGRAM ON CLIMATE CHANGE, AGRIC. & FOOD SEC. (Dec. 14, 2015), https://ccafs.cgiar.org/research-highlight/paris-climate-agreement-unlocks-opportunities-food-and-farming#.WXGAm8fZF5h [https://perma.cc/SS4F-VNSY].

22. Timothy Thomas & Mark Rosegrant, *Climate Change Impact on Key Crops in Africa: Using Crop Models and General Equilibrium Models to Bound the Predictions*, *in* FOOD & AGRIC. ORG. OF THE UNITED NATIONS, CLIMATE CHANGE AND FOOD SYSTEMS: GLOBAL ASSESSMENTS AND IMPLICATIONS FOR FOOD SECURITY AND TRADE 146, 159 (Aziz Elbehri ed., 2015), http://www.fao.org/3/a-i4332e.pdf [https://perma.cc/L7JQ-CQ8D].

impacts to agriculture or food security. The preamble to the Agreement explicitly "recogniz[es] the fundamental priority of safeguarding food security and ending hunger, and the particular vulnerabilities of food production systems to the adverse impacts of climate change."[23] However, the Agreement itself addresses these issues rather tepidly. The only provision in the Agreement that addresses agriculture or food security is Article 2, which provides:

> 1. This Agreement, in enhancing the implementation of the Convention, including its objective, aims to strengthen the global response to the threat of climate change, in the context of sustainable development and efforts to eradicate poverty, including by . . . :
> (b) Increasing the ability to adapt to the adverse impacts of climate change and *foster climate resilience and low greenhouse gas emissions development, in a manner that does not threaten food production* . . . .[24]

While concerns with agriculture and food security are not prominent in the Agreement itself, the GHG emissions commitments made pursuant to it, if met, will greatly reduce the risk of catastrophic consequences to food security. The IPCC has concluded that serious harms will occur if the globe warms more than 2° Celsius.[25] To limit global temperature increase to no more than 2°C, global GHG emissions must be reduced 40–70% by 2050 and carbon neutrality must be attained by the end of the 21st century.[26] Although the Agreement represents an extremely important step in reducing global GHG emissions, even if countries meet all of their commitments, the likely increase in global temperature will be "approximately 2.7 to 3°C at the end of the century."[27] If countries do not meet their Agreement commitments, global warming is expected to be approximately 4.5 to 6°C, which could be catastrophic.[28]

Scientists project that, in the absence of substantial reductions in

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23. Paris Agreement, *supra* note 177, pmbl.

24. *Id.* at arts. 2.1, 2.1(b) (emphasis added).

25. INTERGOVERNMENTAL PANEL ON CLIMATE CHANGE, CLIMATE CHANGE 2007: SYNTHESIS REPORT 48 (2007), http://www.ipcc.ch/pdf/assessment-report/ar4/syr/ar4_syr_full_report.pdf [https://perma.cc/UMX6-T5CB].

26. INTERGOVERNMENTAL PANEL ON CLIMATE CHANGE, CLIMATE CHANGE 2014: SYNTHESIS REPORT 20 (2015), https://www.ipcc.ch/pdf/assessment-report/ar5/syr/SYR_AR5_FINAL_full_wcover.pdf [https://perma.cc/G3US-7763] [hereinafter IPCC 2014 SYNTHESIS REPORT].

27. *2°C Target: Result of State Contributions*, COP21 (Dec. 2015), http://www.cop21.gouv.fr/en/2c-target-result-of-state-contributions/ [https://web.archive.org/web/20170112201404/http://www.cop21.gouv.fr/en/2c-target-result-of-state-contributions/].

28. *Id.*

global GHG emissions, the expected increase in global temperature will produce significant climatic changes that will lead to a multitude of environmental harms, including continued warming, sea level rise, salt water intrusion, increased precipitation and flooding in some areas, increased incidence of drought in many geographic locations, increased frequency of heat waves, and increased intensity of severe weather events. These impacts will have significant consequences for agriculture and food security.[29]

Climate change and agriculture are interconnected in that the existing modern agricultural system contributes significantly to GHG emissions, which in turn contribute to climate change impacts that are likely to adversely affect global food production and prices.[30] The United States, along with most countries in the developed world, employ industrialized agricultural practices that rely heavily on fossils fuel inputs that result in significant GHG emissions. The pesticides and fertilizers used in industrial agriculture are derived from fossil fuels.[31] Farm equipment, such as tractors and combines, and vehicles used to transport agricultural use significant amounts of gasoline and diesel fuel and thus emit significant amounts of GHG combustion byproducts.[32] The food sector accounts for approximately 30% of the world's total energy consumption and contributes more than 20% of GHG emissions.[33]

Industrial agriculture not only significantly contributes to climate change, it also will be extremely vulnerable to the predicted effects of climate change. In fact, our global system of agricultural production as a whole is highly vulnerable to the widespread ecosystem changes that will almost certainly accompany climate change.[34] This vulnerability has the potential to greatly impact the volume and quality of global and regional

29. IPCC 2014 SYNTHESIS REPORT, *supra* note 266, at 58–60, 65.

30. William S. Eubanks II, *A Rotten System: Subsidizing Environmental Degradation and Poor Public Health with Our Nation's Tax Dollars*, 28 STAN. ENVTL. L.J. 213, 267, 269–70 (2009).

31. Jason McKenney, *Artificial Fertility: The Environmental Costs of Industrial Fertilizers*, *in* THE FATAL HARVEST READER: THE TRAGEDY OF INDUSTRIAL AGRICULTURE 121, 121, 127 (Andrew Kimbrell ed., 2002).

32. Jason J. Czarnezki & Elisa K. Prescott, *Environmental and Climate Impacts of Food Production, Processing, Packaging, and Distribution*, *in* FOOD, AGRICULTURE, AND ENVIRONMENTAL LAW 113, 116 (Mary Jane Angelo et al. eds., 2013); *see also* William S. Eubanks II, *The Sustainable Farm Bill: A Proposal for Permanent Environmental Change*, 39 ENVTL. L. REP. 10493, 10504 (2009) (detailing how reliant commodity crops are on fossil fuels).

33. FOOD & AGRIC. ORG. OF THE UNITED NATIONS, "ENERGY-SMART" FOOD FOR PEOPLE AND CLIMATE 49 (2011), http://www.fao.org/docrep/014/i2454e/i2454e00.pdf [https://perma.cc/M7BF-YQGE].

34. Miguel F. Acevedo, *Interdisciplinary Progress in Food Production, Food Security and Environmental Research*, 38 ENVTL. CONSERVATION 151, 156 (2011).

food production, thereby potentially reducing global food security.[35] Climate change will produce a suite of environmental changes that agricultural systems around the world will either have to absorb or adapt, including changes in water availability,[36] mean precipitation,[37] seasonality,[38] and the emergence of new diseases and pests.[39] The ultimate concern regarding the effects of climate change on agriculture is the extent to which these effects negatively alter crop yield, which in turn affects food prices and food security. Crop yields can be impacted by a number of expected climate change impacts, including changes in precipitation, changes in temperature, changes in sea level rise, changes in carbon dioxide levels, and changes in disease and pest outbreaks.[40] There is already evidence that climate change has caused decreased wheat and maize yields in many geographic regions. Experts estimate climate change will cause widespread "decreases in crop yields of 10 to 25 percent and more . . . by 2050."[41] These changes will take place as a growing and generally wealthier population will raise the demand for agricultural production by approximately 60%. Achieving the goal of global food security in the face of these dramatic changes will require innovative and transformative approaches to create a more climate-resilient agricultural system.

Even in the United States and other nations in the developed world, where food security may not be as profound a concern as in the developing world, climate change impacts have the potential to make some regions unsuitable for growing crops, reduce crops yields in other regions, and require more costly practices such as increased pesticide and fertilizer use, more sophisticated and intensive irrigation, and water management systems to grow crops in other regions.[42]

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35. FOOD & AGRIC. ORG. OF THE UNITED NATIONS, CLIMATE CHANGE AND FOOD SECURITY: A FRAMEWORK DOCUMENT 10–11 (2008), http://www.fao.org/forestry/15538-079b31d45081fe9c3dbc6ff34de4807e4.pdf [https://perma.cc/FMX5-R2BH] [hereinafter FAO FOOD SECURITY].

36. IPCC 2014 SYNTHESIS REPORT, *supra* note 266, at 13.

37. *Id.* at 53.

38. *Id.* at 10.

39. *Id.* at 51–52.

40. John R. Porter et al., *Food Security and Food Production Systems*, *in* CLIMATE CHANGE 2014: IMPACTS, ADAPTATION, AND VULNERABILITY 485, 493, 494, 497–99, 508 (2014), http://www.ipcc.ch/pdf/assessment-report/ar5/wg2/WGIIAR5-PartA_FINAL.pdf.

41. FOOD & AGRIC. ORG. OF THE UNITED NATIONS, FAO STRATEGY ON CLIMATE CHANGE (July 2017), http://www.fao.org/3/a-i7175e.pdf [https://perma.cc/B4DV-56J7] (citing IPCC 2014 SYNTHESIS REPORT, *supra* note 266). *See also* Suzanne Goldenberg, *Climate Change 'Already Affecting Food Supply'–UN*, GUARDIAN (Mar. 30, 2014, 8:01 PM), https://www.theguardian.com/environment/2014/mar/31/climate-change-food-supply-un [https://perma.cc/KG42-4G4Y].

42. *Climate Change Impacts, Climate Impacts on Agriculture and Food Supply*, U.S. ENVTL. PROT. AGENCY (2016), https://19january2017snapshot.epa.gov/climate-impacts/climate-impacts-agriculture-and-food-supply_.html [https://perma.cc/D8V9-JHPU] (last visited Aug. 9, 2017).

The U.S. Global Change Research Program predicts climate change will result in decreased yields for many staple crops.[43] Factors that contribute to the likely decreases include less rainfall in many regions resulting in increased droughts and decreased water available to grow crops. In addition, increases in crop damage due to weeds, pest insects, and diseases, are likely to increase in a warmer climate, which can create more hospitable conditions resulting in new pests and diseases moving into areas previously inhospitable due to cold temperatures.[44] Further, salt water intrusion caused by sea level rise will take land in coastal regions out of agricultural production.[45] Moreover, due to the extensive global trade of agricultural products, countries that rely on imports from other regions will be adversely affected regardless of how their domestic production fares under climate change.

For Cuba, the serious climate change consequences are likely to be: reduced arable land due to sea level rise; water contamination with salt as sea level rise decreases available fresh water for irrigation; increased temperature, which can decrease growing seasons in tropical climates and increase pest and disease problems; and extreme weather events, which can destroy crops.

III. THE "GREEN" REVOLUTION PARADOX

A. *The Agricultural Revolution in the United States*

Humans developed agriculture more than 10,000 years ago and up until relatively recently, humans farmed in ways that capitalized on ecosystem services such as pest control via natural predators and parasites, the use of animal and plant waste as fertilizer, and practices that maintained biodiversity on the farm.[46] The technical advances of the "Green Revolution," which occurred from the 1940s though the late 1970s, transformed farming in the United States.[47] The focus of the Green Revolution was on maximizing crop yields for a growing global

43. U.S. GLOBAL CHANGE RESEARCH PROGRAM, U.S. NATIONAL CLIMATE ASSESSMENT, CLIMATE CHANGE IMPACTS IN THE UNITED STATES 151 (2014) http://s3.amazonaws.com/nca2014/low/NCA3_Climate_Change_Impacts_in_the_United%20States_LowRes.pdf?download=1 [https://perma.cc/RRQ3-USE8].

44. *Id.* at 151–57; Simon N. Gosling et al., *A Review of Recent Developments in Climate Change Science. Part II: The Global-Scale Impacts of Climate Change*, 35 PROGRESS IN PHYSICAL GEOGRAPHY 443, 451–53 (2011).

45. FAO FOOD SECURITY, *supra* note 355, at 28.

46. H.F. Van Emden & M.W. Service, *Pest and Vector Management*, *in* PEST AND VECTOR CONTROL 123, 123–35 (2004).

47. Eubanks, *supra* note 300, at 251.

population.[48] To do so, it was necessary to supplement human labor with large inputs of synthetic fertilizers, as well as heavy inputs of pesticides and water.[49] U.S. farming was transformed from a system with a large number of small farms with a diversity of crop types relying primarily on human labor, to that with a small number of fossil fuel intensive highly-mechanized large farms with a greatly reduced number of crop types. Additionally, during this period new federal government policies that linked subsidies to production levels further encouraged high-yield farming.[50] Since the early 1930s, the U.S. Congress has adopted a series of "Farm Bills," which have evolved into the country's comprehensive agricultural policy and tackle a variety of goals, from price support to conservation.[51] A major policy shift in the early 1970s encouraged farmers to produce as much as possible, rather than limit production. The government incentivized maximum production through a complex array of Farm Bill subsidy programs for high yield commodity crops.[52] This policy shift led to the widespread adoption of large-scale industrialized farming practices that required substantial inputs of energy and chemicals and thereby caused significant environmental impacts.[53] These practices dramatically increased per acre crop yields.[54]

Increases in government funding for research and development on high yield agriculture techniques, coupled with the education of farmers in these techniques by a network of agricultural extension agents, also contributed to the dramatic rise in high yield commodity farming.[55] Many consider the Green Revolution a major success because it is estimated to have increased farm production more than 160% over the past 60 years.[56] Paradoxically, these dramatic increases have not alleviated the severe food insecurity that continues to exist in much of the world. The United

48. *Id.*

49. *Id.* at 255, 258.

50. Mary Jane Angelo & Joanna Reilly-Brown, *An Overview of the Modern Farm Bill*, *in* FOOD, AGRICULTURE, AND ENVIRONMENTAL LAW, *supra* note 322, at 14, 14–21; *see also* Karen R. Hansen, *Agricultural Nonpoint Source Pollution: The Need for an American Farm Policy Based on an Integrated Systems Approach Recoupled to Environmental Stewardship*, 15 HAMLINE J. PUB. L. & POL'Y 303, 307–08 (1994).

51. Angelo & Reilly-Brown, *supra* note 500, at 14–21; *see also* Mary Jane Angelo, *Corn, Carbon and Conservation: Rethinking U.S. Agricultural Policy in a Changing Global Environment*, 17 GEO. MASON L. REV. 593, 597 (2010) [hereinafter Angelo, *Corn*].

52. Angelo & Reilly-Brown, *supra* note 500.

53. *Id.*

54. William S. Eubanks II, *A Brief History of U.S. Agricultural Policy and the Farm Bill*, *in* FOOD, AGRICULTURE, AND ENVIRONMENTAL LAW, *supra* note 322, at 1, 5.

55. Angelo, *Corn*, *supra* note 511, at 602.

56. *The Role of Productivity Growth in U.S. Agriculture*, U.S. DEP'T OF AGRIC. ECON. RESEARCH SERV., https://www.ers.usda.gov/data-products/agricultural-productivity-in-the-us/the-role-of-productivity-growth-in-us-agriculture/ [https://perma.cc/AG46-SBS9] (last visited Sept. 1, 2017).

States now produces vast quantities of commodity crops often destined for export, the processed food market, animal feed, or biofuels. But food security cannot be achieved merely through production; it also depends on the ability to make food available and distribute it where needed, which can be influenced by a number of economic, social, and political factors.[57] The Green Revolution thus not only failed to alleviate food insecurity throughout the globe but, unfortunately, the heavy use of fertilizers, pesticides, and water necessary to obtain those high yields also caused significant adverse impacts to human health and the environment.[58]

B. *Industrialized Agriculture: The U.S. Experience*

Industrialized agriculture is characterized by large-scale monocultures[59] of one crop type covering a large area, little or no crop diversity within a single farm, heavy use of synthetic pesticides and chemical fertilizers, and the separation of animal and plant production.[60] Large-scale monoculture agriculture is by definition uniform and so does not support naturally occurring nonchemical pest control and soil nutrient enhancements that, prior to the Green Revolution, were integral components of agriculture.[61]

As monoculture increased, so did the number of pests. Synthetic chemical pesticides developed during the Green Revolution were extremely effective at controlling a wide range of agricultural pests and quickly gained widespread use throughout most regions of the world. Pesticides, which are intentionally released into the environment for the express purpose of killing or disrupting living organisms, often pose significant risks to non-target species, including humans.[62] Some pesticides persist in the environment for weeks, months, and even years.

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57. *See* FOOD & AGRIC. ORG. OF THE UNITED NATIONS, THE STATE OF FOOD AND AGRICULTURE; BIOFUELS, PROSPECTS, RISKS AND OPPORTUNITIES 1, 72 (2008), ftp://ftp.fao.org/docrep/fao/011/i0100e/i0100e.pdf [https://perma.cc/RB5W-3SQD].

58. Angelo, *Corn*, *supra* note 511, at 602; *see also* Eubanks, *supra* note 300, at 251–52, 260 (pointing to the environmental effects of high-yield-crop technology).

59. *See* Helena Norberg-Hodge, *Global Monoculture: The Worldwide Destruction of Diversity*, *in* THE FATAL HARVEST READER, *supra* note 311, at 58, 58–64 (discussing global reliance on monoculture farming).

60. *Industrial Agriculture: The Outdated, Unsustainable System that Dominates U.S. Food Production*, UNION OF CONCERNED SCIENTISTS, http://www.ucsusa.org/our-work/food-agriculture/our-failing-food-system/industrial-agriculture#.WYhtY4QrJhE [https://perma.cc/K87S-5U9A] (last visited Aug. 9, 2017); *see also* Kelley R. Tucker, *Wildlife Harvest*, *in* THE FATAL HARVEST READER, *supra* note 311, at 208, 208–21 (discussing the impacts of agriculture on wildlife).

61. Van Emden & Service, *supra* note 466, at 41–42.

62. *See generally* MARY JANE ANGELO, THE LAW AND ECOLOGY OF PESTICIDES AND PEST MANAGEMENT (Routledge, 2016) [hereinafter ANGELO, PESTICIDES].

Some of these undergo bio-concentration, a phenomenon in which the pesticide concentrates up the food chain, with species at the top of the food chain experiencing high pesticide levels that can cause death or serious harm.[63] Most pesticides are toxic to at least some non-target mammals, birds, reptiles, amphibians, fish, and invertebrates,[64] which can be exposed through direct contact with the pesticide or by ingesting pesticide granules, drinking water contaminated by pesticides, or eating prey organisms contaminated by pesticides.[65] The bans and severe restrictions placed on many pesticides, such as DDT and its relatives, have reduced certain types of risks to wildlife. Nevertheless, pesticides currently in use continue to pose serious risks and have been implicated in both the global amphibian crisis and the global pollinator crisis. Moreover, many chemical pesticides in wide use pose serious risk to humans, particularly to farmworkers and their families who are subject to regular exposure.[66]

One of the most dramatic transformations of the Green Revolution was the separation of animal and plants on the farm.[67] Historically, farmers used on-site animal wastes to enrich soils with nutrients, obviating the need to bring in fertilizer from off-site. The absence of animals on industrialized plant crop agricultural land creates a need for synthetic fertilizers.[68] Conversely, the industrialized livestock model—the concentrated animal feeding operation—produces vast quantities of concentrated animal waste, which significantly contributes to air and water pollution problems rather than soil nutrition. Through this transformation, the U.S. agriculture evolved from being a nutrient sink to being a nutrient source.[69]

Unfortunately, the nutrients contained in synthetic fertilizers, particularly nitrogen and phosphorous, cause substantial water pollution problems[70] and can result in rapid algal growth.[71] An overabundance of algae depletes oxygen and blocks sunlight penetration, which leads to

63. *Id.* at 15–16; *see also* Van Emden & Service, *supra* note 466, at 112.

64. ANGELO, PESTICIDES, *supra* note 622, at 15; *see also* Mary Jane Angelo, *The Killing Fields: Reducing the Casualties in the Battle Between U.S. Endangered Species and Pesticide Law*, 32 HARV. ENVTL. L. REV. 95, 101 (2008) [hereinafter Angelo, *Killing Fields*].

65. ANGELO, PESTICIDES, *supra* note 622, at 89.

66. *Id.* at 56.

67. Angelo, *Corn*, *supra* note 511, at 606–07.

68. *Id.*

69. *Id.*

70. Mary Jane Angelo & Jon Morris, *Maintaining a Healthy Water Supply While Growing a Healthy Food Supply: Legal Tools for Cleaning up Agricultural Water Pollution*, 62 KAN. L. REV. 1003, 1007 (2014); *see also* Jan Lewandrowski, James Tobey & Zena Cook, *The Interface Between Agricultural Assistance and the Environment: Chemical Fertilizer Consumption and Area Expansion*, 73 LAND ECON. 404, 407 (1997).

71. Eubanks, *supra* note 300, at 255–56.

serious environmental damage such as blooms of algal toxic to humans and other species, death of coral reefs, increased fish kills, shifts in fish species populations from desirable species to "trash" species, and overall decreased aesthetic value of the waterbody.[72]

One of the most significant harms of nutrient pollution is that it creates hypoxic areas or "dead zones" in estuaries that previously contained high fish and aquatic organism productivity.[73] There are numerous dead zones throughout the United States and other parts of the world, the most well-known of which is in the northern portion of the Gulf of Mexico, where upstream agricultural run-off of pollution created a dead zone of 16,500 square kilometers (10,250 square miles) along a previously productive area of the coast.[74]

A major concern of nutrient runoff from farms in Cuba is the potential to deteriorate the health of some of the last remaining pristine coral reefs in in the world and some important wetland resources. For example, the Zapata swamp, an area similar to the Florida Everglades and the largest wetland in Cuba, provides many of the same ecosystem functions as the Everglades, such as habitats for wildlife, including rare and protected species;[75] water purification; natural barriers against extreme storm events; and mitigation against sea level rise and salt water intrusion.

In addressing these issues, Cuba could learn from the United States, where industrialized agriculture is a chief contributor to water pollution problems and where the primary U.S. statute designed to protect water resources, the Clean Water Act (CWA),[76] excludes or exempts most agricultural activities from regulation.[77] The CWA has been successful in addressing water pollution from point sources, such as wastewater treatment plants and industrial facilities, but explicitly excludes nonpoint

72. *Id.* at 256. ("[A]s more algae is created from increased chemical nutrients in the water, less oxygen is available for phytoplankton and other organisms in the aquatic ecosystem. When the oxygen slips below a certain level, the water takes on the effects of hypoxia, or a shortage of oxygen. A hypoxic area quickly becomes a "dead zone" because fish and other mobile organisms leave due to the lack of oxygen and all other organisms will die off and cause a food chain collapse."). *See also* U.S. DEPT. OF AGRIC., ARS-163, BEST MANAGEMENT PRACTICES TO MINIMIZE AGRICULTURAL PHOSPHOROUS IMPACTS ON WATER QUALITY 1 (2006), https://naldc.nal.usda.gov/download/26763/PDF [https://perma.cc/RZ8Y-5B7U] (explaining the effect process of phosphorous biosphere contamination); S.R. Carpenter et al., *Nonpoint Pollution of Surface Waters with Phosphorus and Nitrogen*, 8 ECOLOGICAL APPLICATIONS 559, 561 (1998).

73. Angelo & Morris, *supra* note 700, at 1008; *see also* Eubanks, *supra* note 300, at 256.

74. Angelo & Morris, *supra* note 700, at 1008–09.

75. *Flooded Grasslands and Savannahs: Cuba*, WORLD WILDLIFE FUND, http://www.worldwildlife.org/ecoregions/nt0902 [https://perma.cc/XES5-T7EH] (last visited Aug. 7, 2017).

76. Clean Water Act of 1972, 33 U.S.C. §§ 1251–1387 (2012).

77. Angelo & Morris, *supra* note 700; *see also* Mary Jane Angelo & James F. Choate, *Agriculture and the Clean Water Act*, *in* FOOD, AGRICULTURE, AND ENVIRONMENTAL LAW, *supra* note 322, at 147, 147–61.

sources, including most agricultural runoff, from regulation. Consequently, agricultural discharges have become one of the most serious environmental threats in the United States. Finding an economically and technically feasible way to address agricultural discharges has been challenging, in part because the diffuse nature of agricultural discharge from hundreds of thousands of sources make it difficult to impose performance standards or monitor for compliance. Similarly, U.S. pesticide laws are not designed to reduce synthetic pesticide use or promote more sustainable forms of agriculture.[78]

In recent years, U.S. consumers' concerns about the quality and safety of the food they eat and the environmental impacts of industrialized production have led to a rapidly accelerating demand for "organic" foods and other foods grown in more sustainable environmentally friendly ways. Despite this growing demand however, as of 2014, organic sales accounted for only about 4% of U.S. food sales.[79] Moreover, as the organic market has grown, a new form of industrialized agriculture, organic industrialized agriculture, has taken root. Although this type of agriculture has the environmental and health benefits of not using synthetic pesticides and fertilizers, it is still a form of industrialized agriculture that lacks the resilience of agroecology.

C. *The Agricultural Revolution in Cuba*

Prior to 1945, agriculture in Cuba was characterized by marginalized small farmers growing sugar for export markets. After the Cuban revolution of 1959, Cuba joined the Green Revolution and began employing high fossil-fuel input agriculture.[80] During this period, Cuba continued to expand its sugar export market while relying on nearly 50 percent of its food to be imported. By depending so heavily on foreign trade, Cuba lacked food sovereignty and was vulnerable to global political and economic shifts.[81] After the collapse of the Soviet Union in 1991 and the imposition of the U.S. trade embargo, Cuba lost its ability to import chemicals and machinery necessary for industrialized agriculture. Cuba could no longer provide sufficient food for its population. During this period, known as the "special period," the Cuban economy contracted by 35%. Foreign trade fell by an astounding 75%.

78. Angelo, *The Killing Fields*, *supra* note 64, at 134–35.

79. *Organic Market Overview*, U.S. DEP'T OF AGRIC. ECON. RESEARCH SERV., http://www.ers.usda.gov/topics/natural-resources-environment/organic-agriculture/organic-market-overview.aspx [https://perma.cc/N7WU-5QQB] (last visited Aug. 7, 2017).

80. Peter Michael Rosset et al., *The Campesino-to-Campesino Agroecology Movement of ANAP in Cuba: Social Process Methodology in the Construction of Sustainable Peasant Agriculture and Food Sovereignty*, 38 J. PEASANT STUD. 161, 165 (2011).

81. *Id.* at 161.

Without imports, particularly of Soviet oil, farmers could neither rely on chemical inputs nor use tractors and other farm equipment, leading to a 50% reduction in agricultural production.[82] Large industrialized monocultures experienced serious pest damage, leading to decreased crop yields.[83] Food was scarce and people went hungry. Consequently, Cubans started a grassroots movement to grow their own food.

One of the ways Cuba has found to increase food production and availability is through the use of urban farming. A significant portion of Cuba's agroecology is through the establishment of farms and gardens called *organopónicos*, grown on small plots of unused land in urban areas. Cubans living in cities began to utilize abandon lots in urban areas to plant gardens and raise small livestock. In rural areas, farmers started to use old pre-industrial techniques to produce food, substituting human and animal labor for chemical input. For example, the *Organopónico Vivero Alamar* gardens consist of a twenty-seven acre working farm in the center of heavily populated Havana. The farm is organic and diverse, with approximately 140 people involved in growing a wide array of fruits and vegetables without the use of chemical fertilizers or pesticides. Produce from the farm is sold at a farm stand within the city. Vivero Alamar is just one of thousands of urban farms and gardens that can be found throughout Cuba. Some estimate that there are over 380,000 urban farms and gardens in Cuba today. The urban farm and agroecology movement has led to a dramatic increase in healthy organic fruits and vegetables available to Cuban citizens.[84]

Cuba's food crisis also led to a policy shift to increase agricultural production in ways that did not rely on fossil fuels and heavy machinery. Initially, this was accomplished by using inputs that were substitutes for fossil fuel-derived pesticides and fertilizers, but ultimately this system began to evolve into a true agroecology approach.[85] Agroecology know-how was shared at the grass roots level through a movement known as the "campesino-a-campesino" (CAC) movement, established by the National Association of Small Farmers (ANAP).[86]

D. *Agroecology: The Cuba Experience*

Agroecology has five fundamental principles: (1) increasing biomass recycling; (2) improving soil conditions by covering soil with mulch or cover crop; (3) reducing nutrient loss through closed system design; (4) promoting biodiversity within and between species, including landscape

82. *Id.* at 166.
83. *Id.* at 165–66.
84. *Id.* at 165.
85. *Id.* at 168.
86. *Id.* at 170–71.

level biodiversity; and (5) promoting interactions and synergies among system components to encourage ecosystem function such as soil fertility and pest management, without relying on external inputs.[87] Unlike industrialized agriculture, agroecology recycles wastes from animal production into crop fertilizers or biofuel production, so these wastes do not become significant pollution problems.

An important aspect of agroecology is that it is location specific and must be adapted to be successful in different geographical areas and under different conditions. For example, in some places composting may accomplish enhanced sustainability, while in other areas planting green manures may be more successful than composting. The CAC approach relies on strong participation by small farmers who have localized knowledge and community relationships conducive to spreading knowledge and learning.[88] Cuba's small farmers have been successful at quick adaptation of agroecology, and have been open to new innovations and willing to transfer knowledge of sustainable practices at a grassroots level. Researchers have concluded that the CAC movement substantially increased the contribution of peasants to food production and that the rapid spread of agroecology throughout the country was due in large part to this movement.[89] Researchers also believe that the agroecology practices used in the CAC movement benefit agriculture by building resilience to climate change into it.[90] By 2000, the CAC movement had transformed Cuban agriculture into a largely localized agroecology model. Because some agroecological farms were much more successful than others, a system was devised to encourage less successful farms to emulate the most advanced and successful farms, and CAC developed a ranking system to provide information about the level of agroecological integration on a farm.[91]

Although many assume that industrialized agriculture is the sole means of achieving high-yield production, this is not necessarily the case. Studies demonstrate that "the greater the level of agroecological integration, the greater the total value of production, both . . . *per worker* and *per hectare*."[92] For example, vegetable production in Cuba, which had fallen by 65% between 1988 and 1994, had grown approximately 145% over 1988 levels by 2007.[93] This rebound investable production occurred during a time that more than 70% fewer agricultural chemicals were used. By 2009 more than 100,000 families, representing about one

87. *Id.* at 163.
88. *Id.* at 169–70.
89. *Id.* at 176.
90. *Id.* at 183.
91. *Id.* at 174.
92. *Id.* at 177.
93. *Id.* at 181.

third of all families in the peasant sector, had joined the CAC movement.[94] While the majority of agricultural lands in Cuba continue to be state-owned, small farmers or agricultural cooperatives do hold approximately 20% of agricultural land. In addition, Cuba has begun to use long-term land leases to encourage sustainable long-term agriculture and to attract young people back to the farm.

As an island nation in the Caribbean, Cuba is vulnerable to extreme climate events associated with climate change. Experts believe that agroecology is more resilient to extreme climate events and better able to adapt to a changing climate than is industrialized agriculture.[95] In one study, researchers found that after Hurricane Ike, less than 5% of crop plants were left standing in large industrialized monoculture farms.[96] Many of the agroecological systems fared much better and because of their diversity, certain crops were able to compensate for the loss of other crops and even thrive in the changed conditions.[97]

Cuba began studying the potential for climate change impacts on the island in the early 1990s, years before many countries focused on this issue.[98] Climate change could have severe impacts on Cuba, an island nation with a large coastline and more than 3 million people living within one mile of the coast.[99] By the year 2050, estimates predict that rising seas will submerge more than 2% of Cuba's land and that additional lands will be unusable for agriculture due to saltwater intrusion.[100] Cuba's greatest concern is sea level rise although increasing temperatures, heat waves, and extreme events such as large storms, flooding, and drought could also have severe impacts on agricultural production. With regard to agriculture, climate change is likely to result in reduced crop yields, decreases in arable land available for farming, decreases in water quantity and quality available for agriculture, decreases in forest coverage, loss of biodiversity, and increases in pest- and vector-borne diseases. Because Cuba is not highly industrialized and not heavily invested in high fossil fuel dependent agriculture, it has the opportunity to become a leader and model for the type of low carbon future contemplated by the Agreement.

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94. *Id.* at 175.

95. Hilal Elver, *Overcoming Food Insecurities in an Era of Climate Change*, *in* REIMAGINING CLIMATE CHANGE 87, 99 (Paul Wapner & Hilal Elver eds., 2016).

96. *Id.*

97. *Id.*

98. *See* Leticia Martínez & Yaima Puig Meneses, *State Plan to Tackle Climate Change Approved*, GRANMA (May 2, 2017, 6:05 PM), http://en.granma.cu/cuba/2017-05-02/state-plan-to-tackle-climate-change-approved [https://perma.cc/CU9Z-T7SY].

99. *Cuba Population Map*, POPULATION LABS.COM, http://www.populationlabs.com/cuba_population.asp [https://perma.cc/RF8F-8F25] (last visited Aug. 10, 2017).

100. Lea Terry, *Cuba Climate Change Impact: How Scientists Say Global Warming Will Hurt*, NEWSMAX (Nov. 9, 2015, 7:28 PM), http://nws.mx/1WNCxN9 [https://perma.cc/JP95-FFG7].

A significant component of Cuba's low carbon economy potential is the use of ecologically based agriculture, which many believe is necessary to build the type of resilient agricultural systems that can adapt to climate change and ensure future food security.[101]

In addition to the low carbon emissions associated with agroecology, Cuba also could reduce atmospheric carbon through sequestration in biomass in its forests. It is estimated that Cuba's forest removes 14,300,000 tons of carbon dioxide per year. Since the Cuban Revolution in 1959, forested land cover in Cuba has increased from approximately 14%[102] to approximately 30%.[103]

One of the most important factors contributing to the resilience of an ecosystem is biodiversity, which creates redundancies by providing one or more species that can compensate for the loss of other species. These redundancies enable the ecosystem to absorb or adapt to perturbations, including those likely to occur because of climate change.[104] For example, in an ecosystem with high biodiversity, nature provides a complex system of pest control that has evolved over millions of years. Pests, predators, and parasites of pests develop complex interactions wherein the predators and parasites often function as natural pest-control systems.[105] When industrialized agriculture uses monoculture planting, it removes natural pest control systems and makes farms heavily dependent on chemical pesticide inputs.[106] Conversely, agroecology maintains and enhances diversity on the farm by incorporating practices such as intercropping, crop sequencing, and crop rotation.

IV. CUBA'S FOOD SECURITY FUTURE: LESSONS FROM THE UNITED STATES

As this Article describes, the agricultural sectors in the neighboring countries of Cuba and the United States have taken very different paths. As Cuba's economy grows, one of its most important considerations will be whether it will scale up its agroecology approach for domestic and export markets or whether instead it will turn to an industrialized agriculture approach similar to that of the United States to meet growing

101. Rosset et al., *supra* note 800, at 181.

102. Carmen G. Gonzalez, *Seasons of Resistance: Sustainable Agriculture and Food Security in Cuba*, 16 TUL. ENVTL. L.J. 685, 695 (2003).

103. *Forest Area (% of Land Area)*, THE WORLD BANK, http://data.worldbank.org/indicator/AG.LND.FRST.ZS [https://perma.cc/M692-LCQV] (last visited Aug. 9, 2017).

104. Garry D. Peterson, Contagious Disturbance and Ecological Resilience 209 (May 1999) (unpublished Ph.D. dissertation, University of Florida), *available at* http://etd.fcla.edu/etd/uf/1999/amg2055/peterson_g.pdf [https://perma.cc/UT79-ZWVC].

105. Van Emden & Service, *supra* note 61, at 38–39.

106. *Id.* at 41–42.

demand and contribute to a growing economy.

The U.S. experience could provide lessons for Cuba as it develops and grows its economy. Industrialized agriculture, though highly productive, has serious environmental, human health, and socially adverse effects. Moreover, industrialized agriculture lacks the resilience needed to adapt to and withstand the impacts of climate change. This lesson is important as Cuba seeks to increase domestic food production and decrease its reliance on foreign imports of food, chemicals, and equipment necessary to grow food. Industrialized agriculture does not necessarily provide the clearest path to food security and food sovereignty.

The Cuba experience demonstrates that high-yield can be achieved through agroecology. As Cuba adopted the agroecology approach to farming, it became the best performer in terms of agricultural production out of any country in Latin America or the Caribbean.[107] Despite its success and agricultural production, Cuba is still a net importer of food.[108] Cuba currently imports nearly all of its grain from other countries.[109] Heavy reliance on imports can lead to precarious food security and food sovereignty, which could be exacerbated by changing climate conditions.

While Cuba still relies heavily on imported food, its food import dependency is comparable to that of many developed countries, rather than developing countries. Dependence on imported food and inputs necessary for domestic production, however, provides only temporary food security, not long-term security or food sovereignty. Some experts argue that food sovereignty depends on participation from smallholder farmers and a transition to agroecology, which can reduce the dependence on foreign imports, capitalize on local knowledge of local conditions, empower farmers, and ensure the sustainable availability of domestically grown food.[110] Other benefits of agroecology include increased autonomy and control, improved soil fertility, producing and making available locally grown healthy food, and greater economic sustainability of smallholder farming.[111] All of these benefits combine to improve food sovereignty and food security.

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107. Rosset et al., *supra* note 800, at 167.

108. *Cuba: Current Issues and What the World Food Programme is Doing*, WORLD FOOD PROGRAMME, https://www.wfp.org/countries/cuba [https://perma.cc/E96Q-HUYL] (last visited Aug. 10, 2017).

109. Chris Lyddon, *Focus on Cuba*, WORLD-GRAIN.COM, http://www.world-grain.com/Departments/Country-Focus/Country-Focus-Home/Focus-on-Cuba.aspx?cck=1 [https://perma.cc/8H29-KPJX] (last visited Aug. 10, 2017).

110. *Agroecology: Resilient and Productive*, PESTICIDE ACTION NETWORK NORTH AMERICA, http://www.panna.org/agroecology-farming-solutions/agroecology-resilient-productive [https://perma.cc/AXQ8-6BL6] (last visited Aug. 10, 2017).

111. FOOD & AGRIC. ORG. OF THE UNITED NATIONS, FAO IN ACTION, HEALTHY SOILS ARE THE BASIS FOR HEALTHY FOOD PRODUCTION (2015), http://www.fao.org/fileadmin/user_upload/soils-2015/docs/EN/EN_Print_IYS_food.pdf [https://perma.cc/MM36-W5J7].

In addition to using agroecology to provide for its own food security, Cuba could develop an "organic" export market.[112] To do so, Cuba would need to meet the standards of the importing country. The U.S. organic certification program, for example, administered under the Organic Foods Production Act (OFPA),[113] establishes a voluntary federal program in which producers can label their product USDA-certified and "organic" if production, handling, and labeling of the product were performed according to certain standards.[114] One of the primary factors the OFPA uses to determine whether a product is "organic" is whether farmers used certain prohibited products such as synthetic fertilizers, antibiotics and growth hormones in livestock, and other synthetic ingredients prohibited by the program standards.[115] The United States does not require ecologically based agriculture in order for a product to be considered organic and, in fact, much of U.S. organic agriculture has evolved into large-scale industrialized agriculture that merely substitutes allowable pesticides and fertilizers for prohibited ones.

The European Union (E.U.) organic standards are similar to those of the United States in some respects, but differ in that rather than focusing on prohibiting certain pesticides and fertilizers in organic production, the E.U. standards encompass a broader set of environmental concerns including pollution, renewable energy, humane treatment of animals, and biodiversity.[116]

The development of agriculture that meets either U.S. or E.U. organic standards could provide a significant export market for Cuba's agricultural products. However, in a time of changing climate with more disease pests, too much or too little water, contaminated water, and less arable land, the most important focus for development of the agricultural sector should be providing food security and food sovereignty for the people of Cuba. The country will best accomplish this through ecologically based agriculture.

V. CONCLUSION

Despite the success of the Cuban agroecological movement in

112. *See generally* Wesley J. Hevia et al., *Seizing the "Organic" Moment: Cuba's Agricultural Crossroads and Certified Organic Export Potential*, 21 DRAKE J. AGRIC. L. 297 (2016).

113. Organic Foods Production Act, 7 U.S.C. § 6504(1)–(3) (2012).

114. §§ 6503(a), 6518(a). The OFPA directs the Secretary of Agriculture to establish a National Organic Production Program (NOPP) and a National Organic Standards Board (NOSB) to advise the Secretary regarding program standards.

115. 7 U.S.C. §§ 6508(b)(1), 6509(c)(3), 6510 (2012).

116. Council Regulation 834/2007, On Organic Production and Labeling of Organic Products and Repealing Regulation, 2007 O.J. (L 189) 1.

carrying Cuba through its food crisis and dramatically reducing reliance on imports, new challenges from an expanding economy may push Cuba back into an industrialized agricultural model. The U.S. experience demonstrates that industrialized agriculture brings with it a plethora of human health and environmental harms. These externalized costs cannot be ignored when projecting the benefits of an industrialized agriculture future in Cuba. In many ways, Cuba has even more to lose than does the United States. Currently, Cuba is home to some of the most pristine coral reefs and productive wetland systems in the world.[117] Agricultural pollution poses a serious risk of contamination to these reefs and other important water resources, which could impact Cuba's future in terms of fish and seafood production, as well as in recreation and tourism. Looking to U.S. law, however, will not help Cuba because the United States does not provide adequate protection from the environmental harms associated with industrialized agriculture. Environmental laws, such as the CWA, exclude or exempt most agricultural pollution from regulation.[118] U.S. pesticide law is based on a cost/benefit balancing approach, which does not prioritize environmental concerns over economic concerns.[119] U.S. agricultural policies, through a variety of subsides, encourages high-yield large-scale full-industrialized monoculture production of a few commodity crops. If Cuba wants to avoid the serious human health and environmental risks of industrialized agriculture, it needs to ensure that it enacts sufficient regulatory authority and enforcement to address non-point source agricultural pollution and the impacts of widespread synthetic pesticide application on humans, wildlife, and the environment. Moreover, Cuba could learn from the U.S. program of agricultural subsidies, which encouraged highly productive commodity production that does not ensure food security, food sovereignty, or a healthy domestic food supply.

Cuba is currently internationally recognized as a leader in climate-resilient agroecology[120] and is not a significant contributor of GHG emissions.[121] If Cuba can find a way to scale up its agroecology without

117. *Cuba: Unspoiled Coral Reefs Awe Scientists*, THE NATURE CONSERVANCY, http://www.nature.org/ourinitiatives/regions/caribbean/cuba/cubas-unspoiled-coral-reefs.xml [https://perma.cc/8Q29-LY5G] (last visited Aug. 10, 2017).

118. MEGAN STUBBS, CONG. RESEARCH SERV., R41622, ENVIRONMENTAL REGULATION IN AGRICULTURE 15 (2014), https://www.fas.org/sgp/crs/misc/R41622.pdf [https://perma.cc/48QA-BDH8].

119. *See generally*, Mary Jane Angelo, *Embracing Uncertainty, Complexity, and Change: An Eco-pragmatic Reinvention of a First-Generation Environmental Law*, 33 ECOLOGY L.Q. 105 (2006) *and Risk/Benefit Balancing Under FIFRA, Pesticide Safety Education Program*, CORNELL UNIVERSITY COOPERATIVE EXTENSION (2012), http://psep.cce.cornell.edu/issues/risk-benefit-fifra.aspx [https://perma.cc/A9EM-Z8WC].

120. Rosset et al., *supra* note 800, at 182.

121. WORLD RESOURCES INSTITUTE, *CAIT Climate Data Explorer: Cuba: Country GHG*

becoming industrialized and without relying on high fossil fuel inputs, then Cuba could serve as a model for other small countries of how to achieve food security and sovereignty resilience in a low carbon economy.

Emissions, http://cait.wri.org/profile/Cuba [https://perma.cc/N3S2-ALGS] (last visited Aug. 9, 2017).

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