# Eco-Friendly Alternatives for Feeding 9 Billion People

By:

Liz Goss

Washington University

International Affairs

Professor Hudson/ Professor Schindler

Directive Research Project

December 5, 2010

# Table of Contents



# List of Figures



# List of Tables

# Introduction

Some might say that diminishing fresh water resources is the biggest threat that the world faces today. Others believe it is greenhouse gases and climate change. For villagers in areas of Asia and Africa who are going to sleep hungry every night, in their world, food scarcity could be the biggest threat. The common denominator of these and many other global crises is arguably overpopulation.

Reverend Thomas Robert Malthus had many enemies due to his harsh outlook and treatment of the poor. He predicted that the world would eventually endure mass starvation as he was witnessing a population growth that he believed agriculture could not sustain. He supported the Poor Law Amendment Act of 1834 to minimize charity for the poor while implementing standards of harsh living conditions, including less wages or forced emigration, as he blamed the poor for causing this eventual catastrophe by increasing their fertility rate to six children.[1] In 1798, Malthus published *Essay on the Principles of Population,* which stated his findings that population growth leads to war, famine and diseases, while abstinence, birth control and marrying at a later age would secure society's chances for a better life.[2]

During the time that Malthus was witnessing what he believed to be a population explosion, the number of people living in England doubled in 50 years, from 1750 to 1800, and then doubled again within the next 30 years to 24 million.[3] Malthus may have underestimated the human ability to adapt to limited space and resources as England's population is now

---

[1] Fred Pearce, *The Coming Population Crash* (Boston: Beacon Press, 2010), 7.

[2] John Avery, "Malthus' Essay on the Principle of Population," *University of Copenhagen,* 31 May 2005, http://www.learndev.org/dl/MalthusEssay-Avery.pdf. (accessed 29 Nov 201)

[3] Pearce, , *The Coming Population Crash,* 6.

approximately 52 million, but concerns regarding his theory of exceeding the planet's carrying capacity remains.[4]

Food shortage continues to be a threat worldwide; however, some regions are exposed to hunger more than others. Sparked by his own experience of his community teetering on the verge of starvation in Minnesota during the Great Depression, Norman Borlaug developed an interest in food production. By crossing varieties of wheat to obtain the desired traits capable of enduring diseases and the climate in Mexico, Borlaug was able to produce the yields required for meeting the increasing demands of the country.[5] With the combination of pesticides and fertilizers on his high yielding strains of wheat and rice, Borlaug won the Nobel Peace Prize for his successful crops in Mexico, Asia and Africa, from the 1960s to the 1980s, that saved up to a billion lives, deeming him the father of the "Green Revolution".[6] Borlaug realized that increasing crop yields is just an immediate fix to a greater problem. He urged his listeners to embrace the technology of chemicals with genetic variations, while also warning of implications of relying on conventional farming as the solution for eradicating world hunger. He believed that mankind would need to act responsibly with population control for the possibility of a decent quality of life for every person.[7]

---

[4] Office of National Statistics, "Population Estimates for UK, England, Wales, Scotland and North Ireland," *Statistics.gov.uk,* 30 Jun 2009, http://www.statistics.gov.uk/statbase/Product.asp?vlnk=15106. (accessed 30 Nov 2010)

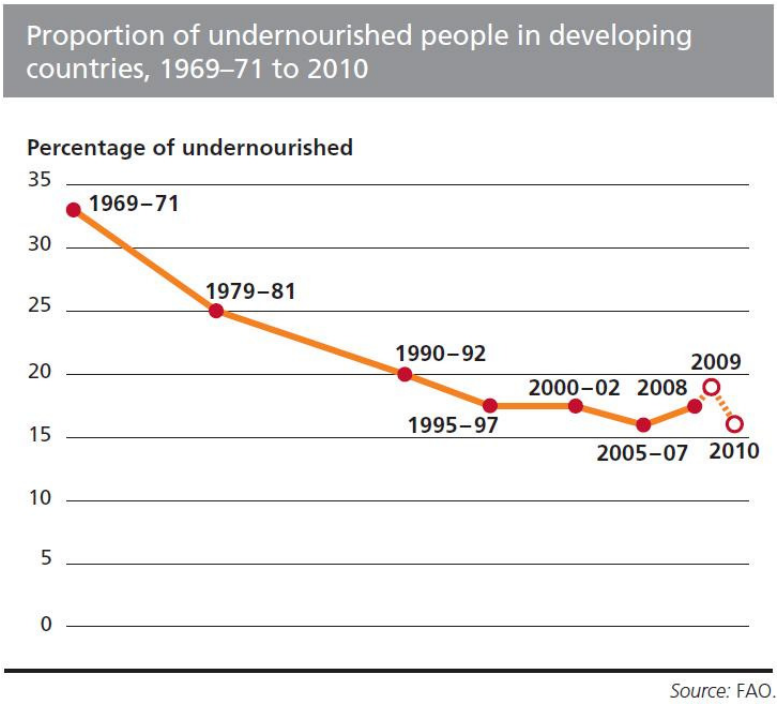
[5] Justin Gillis, "Norman Borlaug, Plant Scientist Who Fought Famine, Dies at 95," *NYTimes.com,* 13 Sep 2009, http://www.nytimes.com/2009/09/14/business/energy-environment/14borlaug.html?pagewanted=1&_r=1. (accessed 29 Nov 2010)

[6] Matt Curry and Betsy Blaney, "Borlaug, Who Saved Millions from Hunger, Dies," *USAToday.com,* 14 Sep 2009, http://www.usatoday.com/tech/science/2009-09-14-borlaug-obit_N.htm. (accessed 29 Nov 2010)

[7] Joe Holley and J.Y. Smith, "The Father of the Green Revolution," *WashingtonPost.com,* 14 Sep 2009, http://www.washingtonpost.com/wp-dyn/content/article/2009/09/13/AR2009091300375.html. (accessed 29 Nov 2010)

Figure 1

**Undernourished People in Developing Countries, 1969-71 to 2010**




Source: FAO, " Hunger," *FAO.org*, 2010, http://www.fao.org/hunger/hunger_graphics/en/. (accessed 2 Dec 2010)

Note: Agricultural yields increased to reduce the number of undernourished people in developing countries, but the level of production has been slowing while population continues to grow.

The multiplying global population is a valid cause for concern as it compromises food safety and security. Measures are taken to increase food supply by using more chemicals on livestock and crops for higher earnings and investment protection. Incidences of natural disaster are on the rise, destroying food crops and leaving communities dependent on food aid. The cost of oil continues to increase, pricing food out of the reach of many in developing countries while also reducing food aid as transportation costs reflect oil prices. Farmers struggle with food production as prices for chemical fertilizers and pesticides continue to rise, offsetting the increasing yields from their use.

As the global population approaches 7 billion, the question is frequently raised as to whether current agricultural processes are capable of fulfilling the growing need. Many critics would simply refer to the year 2009 with the new record high of 1.02 billion undernourished people.[8] Or maybe the fact that starvation kills a person every 3.6 seconds.[9] Borlaug's green revolution was successful in defeating world hunger for several decades but was designed to feed the population at the time, not an expanding one.

This paper will discuss current agricultural processes, or conventional farming, to understand why the system is failing to feed the global population. The implications to the environment and the farm workers, if these farming methods continued to be used, will also be reviewed. Alternative solutions will be explored that will not only help conserve resources but may be the juncture that could possibly create food security in regions of the world that consistently experience hunger.

## History

The notion of producing food, rather than hunting and gathering, has undergone continuous modification over thousands of years. Changes have been constant, but whether they are improvements is a fraught question. Agricultural techniques emerged approximately 11,000 to 12,000 years ago.[10] Up to that point, hunting and gathering had been the chief method of feeding groups. As the men hunted, women would walk in search of food,

[8] FAO, "Economic Crisis is Devastating for the World's Hungry," *fao.org,* 14 Oct 2009, http://www.fao.org/news/story/0/item/36207/icode/en/. (accessed 29 Nov 2010)

[9] Peter Lu, "World Hunger Dangers Exacerbated by Environment," *YaleHerald.com,* 19 Feb 2010, http://yaleherald.com/opinion/world-hunger-dangers-exacerbated-by-environment/. (accessed 29 Nov 2010)

[10] Spencer Wells, *Pandora's Seed* (New York: Random House, 2010), 40.

frequently covering several miles daily. Communities were not established, so it was necessary for people to travel in small groups in order to follow the herds and other sources of food by the seasons. The Natufian people originated from the eastern region of the Mediterranean and existed from 12,500 BC to 9,500 BC.[11] A sudden, short ice age called the Younger Dryas killed much of the wild cereal on which they heavily relied, resulting in planting seeds rather than migrating for food.[12] It is believed that this civilization was the first to develop a successful agricultural technique, albeit serendipitously.

The development of agriculture occurred simultaneously throughout inhabited areas worldwide, also allowing for societies to become more sedentary, which in turn led to population growth. Two of the earliest establishments were located in the areas that are now known as Turkey and the Middle East. By 6,000 B.C., there were more than a thousand homes in Catal Huyuk while 2,000 to 3,000 people settled in Jericho.[13] A spring supplied the region with an abundance of water, allowing for the expanding community to plant larger crops of barley, wheat, lentils, and peas. Within the same time span, farmers from Indonesia and China began harvesting rice, soy, mung and azuki, while trolling the waters with nets to catch fish.[14]

Just as plants had become domesticated, so did animals. A jawbone dating back to 10,000 B.C. demonstrates a smaller jaw and teeth of a bred wolf, proving that dogs were the

---

[11] "Natufian Culture," *Natufian.com*, 12 Jul 2010, http://www.natufian.com/. (accessed 27 Sep 2010)
[12] Ibid.
[13] "Story of Farming," *History Link 101,* 2004, http://www.historylink101.com/lessons/farm-city/story-of-farming.htm. (accessed 28 Sep 2010)
[14] "Agriculture," *GDFarm.info,* 2007, http://www.gdfarm.info. (accessed 28 Sep 2010)

first animal to become dependent on humans.[15] While these dogs were used to help in the hunting process, goats and sheep were next to be domesticated. This development allowed for hunters to begin a gradual transition to hunting only particular animals and then, eventually, to become herders.[16] These domesticated animals complemented the crops as they provided protein and milk, as well as peace of mind, due to the immediate food source without the need for being constantly on the move.

People from neighboring regions began trading grains, animals, tools, and ideas. Bartering became part of life for thousands of years to come. As survival was becoming more dependent on agriculture, the necessity to protect crops from insects and undesirable plants was crucial. Farmers relied on pesticides to kill any insects, weeds, or animals that may threaten them or their food supply. The Sumerians (from the region between the Euphrates Valley and the Tigris) were among the first to use pesticides. In 2,500 BC, they began to spread the foul odors of sulfur compounds on their skin as an insect repellant.[17] Approximately 1,500 to 3,000 years later, Pliny, Homer, Artistotle, and Cato discussed the use of pesticides in their writings in the forms of oil sprays, fumigants, sulphur ointments, and arsenic.[18] Taking natural measures was just as effective. The Chinese protected their citrus trees from threatening beetles and caterpillars by connecting branches with bamboo and rope to assist predatory ants

---

[15] Bamber Gascoigne, "History of the Domestication of Animals," *History World,* 2001, http://www.historyworld.net/wrldhis/PlainTextHistories.asp?groupid=1825&HistoryID=ab57&gtrack=pthc. (accessed 28 Sep 2010)

[16] Anil K. Gupta, "Origin of Agriculture and Domestication of Plants and Animals Linked to Early Holocene Climate Ameliorate," *Current Science,* 10 Jul 2004, http://www.ias.ac.in/currsci/jul102004/54.pdf. (accessed 28 Sep 2010)

[17] Eric Taylor, A. Gordon Holley and Melanie Kirk, "Pesticide Development: A Brief Look at History," *Southern Regional Extension Forestry,* Mar 2007, http://library.rawlingsforestry.com/sref/pesticide_development/sref-fm-010.pdf. (accessed 27 Sep 2010)

[18] Jules Pretty, *The Pesticide Detox* (London: Earthscan, 2005), 1.

to eliminate the unwanted insects.[19] The first documented use of herbicides, or pesticides, targeting weeds, was documented in 300 B.C. by a botanist who poured olive oil on the roots of young unwanted trees.[20]

Olives played other vital roles in the development of pesticides. A Roman named Marcus Terentius Varro discovered a key ingredient that became the base component of many pesticides.[21] Amurca is a by-product of olives pressed for oil and is highly effective in killing plants and insects when salt is added.[22] Various ingredients were combined with amurca, depending on the target of the pesticide, but this olive substance was believed to be the fundamental component of all pesticides for centuries to come.

Weed and pest control progression was at a standstill until the mid-1600s when rotenone, a natural chemical extracted from the roots of tropical plants, was discovered to cause fish to float and die by paralyzing them. During Europe's agriculture revolution, which occurred between 1750 and 1880, tobacco extracts were found to protect pears from lace bugs while rotenone became popular once again as a pesticide targeting leaf-eating caterpillars.[23] Scientists began experimenting with fungicides, creating a copper sulfate solution in 1807,[24] to protect wheat from the fungal bunt disease which reduces the quality and quantity of grain produced.[25] Over the next decade, several mixtures were created to protect crops from insects

---

[19] Taylor, "Pesticide Development: A Brief Look at History."
[20] Ibid.
[21] Ibid.
[22] John Humphrey, John Olsen and Andrew Sherwood, *Greek and Roman Technology (New York: Routledge, 1998),* 96.
[23] Taylor, "Pesticide Development: A Brief Look at History."
[24] Ibid.
[25] USDA, "Karnal Bunt: A Fungal Disease of Wheat," APHIS.USDA.gov, Jul 2001, http://www.invasive.org/publications/aphis/karnel.pdf. (accessed 30 Nov 2010)

and weeds by using ingredients such as lead-arsenate and organic mercury compounds, but were taken off of the market by the 1960s since they are toxic to humans.[26]

Pesticides became more popular and widely used in the 1960s, at a time when farmers were restricted by the acreage of their crops due to agricultural programs.[27] From the 1970s through the early 1980s, pesticide sales saturated the market as U.S. commodity exports, yield prices, and acreage size were all increasing. This peak was shortly followed by a decrease in pesticide use, which reflected the drop in crop prices and acreage.[28] The 1990s showed promise once more for pesticide sales as program restrictions became less strict, allowing for growth in acreage and crop prices.[29]

## The Effects of Agriculture

Field after field of corn, soy beans, cotton, or any crop appear at first sight to be peaceful and harmless. Unfortunately, this is far from the truth. The destruction that is caused by any conventional crop is devastating to the environment and its inhabitants, human or animal, downstream, regionally, and globally. As the world population increases, farmers are forced to be more productive by using every possible means, even though their resources are diminishing.

The global population is currently growing at a rate of 1.133 percent,[30] or an additional 70 million people, annually.[31] Land use, or modifying the Earth's surface to meet the needs of

[26] Taylor, "Pesticide Development: A Brief Look at History."
[27] Craig Osteen and Merritt Padgitt, *Pesticides in Agriculture and the Environment* (New York: Marcel Dekker, 2002), 80.
[28] Ibid.
[29] Ibid.
[30] "Population Growth Rate," *CIA World Factbook,* 29 Sep 2010, https://www.cia.gov/library/publications/the-world-factbook/geos/xx.html. (accessed 4 Oct 2010)

its expanding population, is occurring with increasing frequency. Much of the land that nature intended for farming has already been stripped of its nutrients, forcing farmers to develop new areas for crops, livestock, feed, biofuels, and fibers. Some farmers are destroying the bio-diversity and eco-systems of rainforests to use the fertile soil for planting their next harvest. Others will use the land for livestock; for instance, in Latin America, seventy percent of the Amazon forest has been converted to land for cattle grazing.[32] Soon this land will be depleted of nutrients, becoming vulnerable to fires and erosion by wind and rain. Farmers are then faced with the responsibility of continuing the cycle.

Approximately 40 percent of the world's land has been converted for agriculture, or an area the size of South America for crops and another 8.5 billion acres for livestock.[33] Forests acting as carbon sinks to produce oxygen from carbon dioxide are being destroyed at the rate of 860 acres, or one Central Park, every 15 minutes in the tropical regions.[34] As land is converted for agricultural use, the process contributes to global climate change, pollution of the air, water and land, and depletion of fresh water. Habitats are being destroyed, resulting in extinction for millions of plants and animals— many of which have yet to be discovered.

Although many believe that greenhouse gas (GHG) is the most pressing environmental global issue today, diminishing fresh water resources may be the most immediate and crucial dilemma that the world has encountered. The lack of fresh water has been responsible for

---

[31] Jonathan Foley, "The Other Inconvenient Truth: The Crisis in Global Land Use," *Yale Environment 360,* 5 Oct 2009, http://e360.yale.edu/content/feature.msp?id=2196. (accessed 2 Oct 2010)

[32] Christopher Matthews, "Livestock a Major Threat to the Environment," *FAO Newsroom,* 29 Nov 2006, http://www.fao.org/newsroom/en/news/2006/1000448/index.html. (accessed 5 Oct 2010)

[33] James Owen, "Farming Claims Almost Half Earth's Land, New Map Shows," *National Geographic News,* 9 Dec 2005, http://news.nationalgeographic.com/news/2005/12/1209_051209_crops_map.html. (accessed 3 Oct 2010)

[34] Nick Hopwood and Jordan Cohen, "Greenhouse Gases and Society," *University of Michigan,* 29 Dec 2008, http://www.umich.edu/~gs265/society/greenhouse.htm. (accessed 4 Oct 2010)

sickness, death, environmental refugees and threats of war. Death caused by insufficient or unsanitary water claims the lives of over a million children and infants every year while hundreds of millions experience pain and illness.[35] Changes in climate patterns have led to a depletion of water without replenishment, causing the Sahara to have more refugees from the environment than from war.[36] Natural disasters that were climate-induced resulted in an additional 20 million environmental refugees in 2008 alone,[37] contributing to the projected 50 million by 2010.[38] Climate change has caused droughts worldwide, lowering water levels in rivers and lakes, and has impeded aquifers from being replenished. With the fresh water supply already in dire straits, many countries have no allowance for waste.

Agriculture consumes 70 percent of the world's fresh water for irrigation.[39] Unfortunately, most farming regions of the world are already facing a fresh water shortage. Still, rivers, lakes and aquifers continue to be drained for irrigation, depriving communities of fresh water for personal crops, livestock, drinking, and sanitation. Many aspects of our daily lives depend on the water used in agriculture. From the initial planting of the cotton seeds to the production of the final good, the amount of water used to make one cotton T-shirt consumes 719 gallons of water.[40] Depending on the region where the corn is produced, 69 to

---

[35] The Worldwatch Institute, *State of the World 2007: Our Urban Future* (Washington, DC: Worldwatch Institute, 2007), 27.

[36] Wells, *Pandora's Seed,* 182.

[37] Siri Elverland, "20 Million Climate Displaced in 2008," *Norwegian Refugee Council,* 22 Sep 2009, http://www.nrc.no/?did=9429522. (accessed 17 Nov 2010)

[38] Thalif Deen, "U.N. Braces for a New Breed of Refugees," *IPS News*, 23 May 2007, http://ipsnews.net/news.asp?idnews=37860. (5 Oct 2010)

[39] Dickson Despommier, "Growing Skyscrapers: The Rise of Vertical Farms," *ScientificAmerican.com,* 16 Nov 2009, http://www.scientificamerican.com/article.cfm?id=the-rise-of-vertical-farms. (accessed 8 Nov 2010)

[40] Chapagain, A.K., et al., "The Water Footprint of Water Consumption," *UNESCO-IHE Institute for Water Education*, September 2005, http://www.waterfootprint.org/Reports/Report18.pdf. (accessed 1 Dec 2010)

565 gallons of water is used to produce the corn and to convert it into one gallon of ethanol.[41] Five hundred gallons are used to produce just one pound of rice, and a thousand gallons are consumed to produce the feed for cattle in order to provide one pound of beef.[42]

Along with the immense amount of water used in agriculture, contamination and waste play a key role in water pollution. *Dead zones* are areas in bodies of water where forms of life cannot exist due to the depletion of oxygen. The increasing demand for corn for food, livestock feed, and, most of all, ethanol has resulted in the planting of more crops, leading to bigger yields that require additional fertilizers containing phosphorus and nitrogen.[43] The runoff from these compounds has caused dead zones, such as the one in the Gulf of Mexico that spans almost 8,000 square miles.[44]

Air pollution caused by agriculture adds an immense amount of greenhouse gases, further complicating climate change. Forests are frequently leveled using the highly polluting methods of slash and burn or clear cutting. The carbon retained in forests is released along with methane and nitrous oxide, contributing 30 percent of all greenhouse gases.[45] Nitrous oxide and methane are significant factors in the measurements of GHG as nitrous oxide has a global warming potential 310 times greater, and methane 21 times greater, than that of carbon

---

[41] Phil McKenna, "Measuring Corn Ethanol's Thirst for Water," *Technologyreview.com,* 14 Apr 2009, http://www.technologyreview.com/energy/22428/. (accessed 17 Nov 2010)

[42] Wells, *Pandora's Seed,* 181.

[43] NOAA, "CSCOR Director Rob Magnien Discusses the Challenges of Using Biofuels to Produce Energy," *coastalscience.noaa.gov,* 15 Sep 2009, http://cc.bingj.com/cache.aspx?q=gulf+of+mexico+dead+zone+corn&d=4772005155897530&w=a8fac555,b534f5e (accessed 23 Oct 2010)

[44] Joel Achenbach, "A 'Dead Zone' in the Gulf of Mexico," *Washingtonpost.com,* 31 July 2008, http://www.washingtonpost.com/wp-dyn/content/story/2008/07/31/ST2008073100349.html?hpid=topnews. (accessed 23 Oct 2008)

[45] Foley, "The Other Inconvenient Truth."

dioxide.[46] Taking into consideration all anthropogenic contributions of GHG, livestock is responsible for 9 percent of carbon dioxide, 65 percent of the nitrous oxide, and 37 percent of the methane.[47] Contributions from livestock will only become progressively worse as meat will continue to be a growing industry.

## Pesticides and Herbicides

As agriculture continues to reflect the growth of the population, crop acreage expands, more food is planted, and farmers' reliance on pesticides builds. Pesticides have become almost as crucial to the farming process as water. Unfortunately, these chemicals can do as much harm as good.

Pesticides and herbicides are used to protect farmers' investments by eliminating insects and weeds. However, these chemicals are frequently overused as farmers spray additional applications to remove even the possibility of a threat. Although the concept of using the pesticide as a preventive measure sounds good in theory, the fact remains that many pests will build a resistance, resulting in the application of even more chemicals. The excessive use poisons the soil, groundwater, and air within the vicinity.

Pesticides are susceptible to volatilization, or converting from a liquid into a gas, which can then easily disseminate into the atmosphere, putting any living organism in its path at

[46] Elizabeth Scheehle, Dave Godwin, Deborah Ottinger and Benjamin DeAngelo, "Global Anthropogenic Non-CO2 Greenhouse Gas Emissions: 1990-2020," *EPA.gov,* June 2006, http://www.epa.gov/climate/climatechange/economics/pdfs/GreenhouseGasReport.pdf. (accessed 5 Oct 2010)

[47] Matthews, "Livestock a Major Threat to the Environment."

risk.[48] One documented incident showed lindane pesticide, which was pulled from the EPA's list of authorized chemicals, to have travelled 1,500 kilometers (932 miles) before the rainfall deposited the molecules into a remote lake.[49] An estimated 0.5 to 5 percent of the total amount applied is lost by ways of vaporization (which will return in rain water), absorption into the soil, flow through drains or cracked soil, surface water that contaminates areas downstream, or pass through to the groundwater.[50] The process of negatively-charged particles of the soil becoming attracted to the pesticide molecules that are positively charged is called pesticide adsorption, resulting in organic soil or clay to be more susceptible to contamination because of their large surface area.[51] Due to adsorption, farmers are encouraged to use more pesticides for higher effectiveness.

Cotton is an essential commodity not only for the fibers, which account for 24 percent of the boll (part of the plant consisting of the fibers and seeds), but also for 36 percent of the cottonseed that is used in foods as cottonseed oil and the remaining 40 percent (stems, leaves and burs) are used in livestock feed after it is mixed with molasses.[52] Unfortunately, this plant that is relied on for clothes, food, fertilizer, and cattle feed takes an enormous toll on the environment. It not only uses more water than any other crop, but also requires the greatest amounts of pesticides, as well as the most toxic ones.[53]

---

[48] Ibid.
[49] Jules Pretty, *The Pesticide Detox* (London: Earthscan, 2005), 13.
[50] Ibid.
[51] University of Missouri, "Pesticides and the Environment," *University Extension,* Sep 91 http://extension.missouri.edu/explorepdf/agguides/pests/G07520.pdf. (accessed 11 Oct. 2010)
[52] Pietra Rivoli, *The Travels of a T-Shirt in a Global Economy* (Hoboken: John Wiley & Sons, 2009), 51.
[53] Environmental Justice Foundation, "The Deadly Chemicals in Cotton," *EJFoundation.org,* 2007, http://www.ejfoundation.org/pdf/the_deadly_chemicals_in_cotton.pdf. (accessed 15 Oct 2010)

The disastrous effects that agriculture and pesticides could have on the environment and humans can be witnessed in certain regions of Kazakhstan, Uzbekistan, and the Aral Sea. This region is experiencing the most extreme consequences as a result of continuous use of unsustainable farming processes, yielding a scenario that could become more prevalent globally with conventional farming. The Amu Darya and Syr Darya rivers were dammed to divert the water to irrigate cotton crops, causing 85 percent of the Aral Sea to dry up and allowing only 4 of the 24 native fish to remain in existence today.[54] The remaining water, which is extremely salty and toxic, has led to severe health issues among the people relying on this water source, such as increased infant mortality, decreased life expectancy from 64 to 51, endemic anemia, and alarmingly high esophageal cancer rates.[55] Desertification has ravaged what had been the fourth largest sea in the world, leaving the ground vulnerable for the winds to displace 77 million tons of dust containing DDT, salt, and pesticides each year, affecting food crops, humans, and animals within the region.[56] Without an abundant supply of fresh water to irrigate the once fertile soil, salinization has denied the land the ability to grow more crops, forcing farmers to source the nutrient-rich soil of the Tugai Forest where 80 percent of the land has already been converted into cotton fields.[57]

---

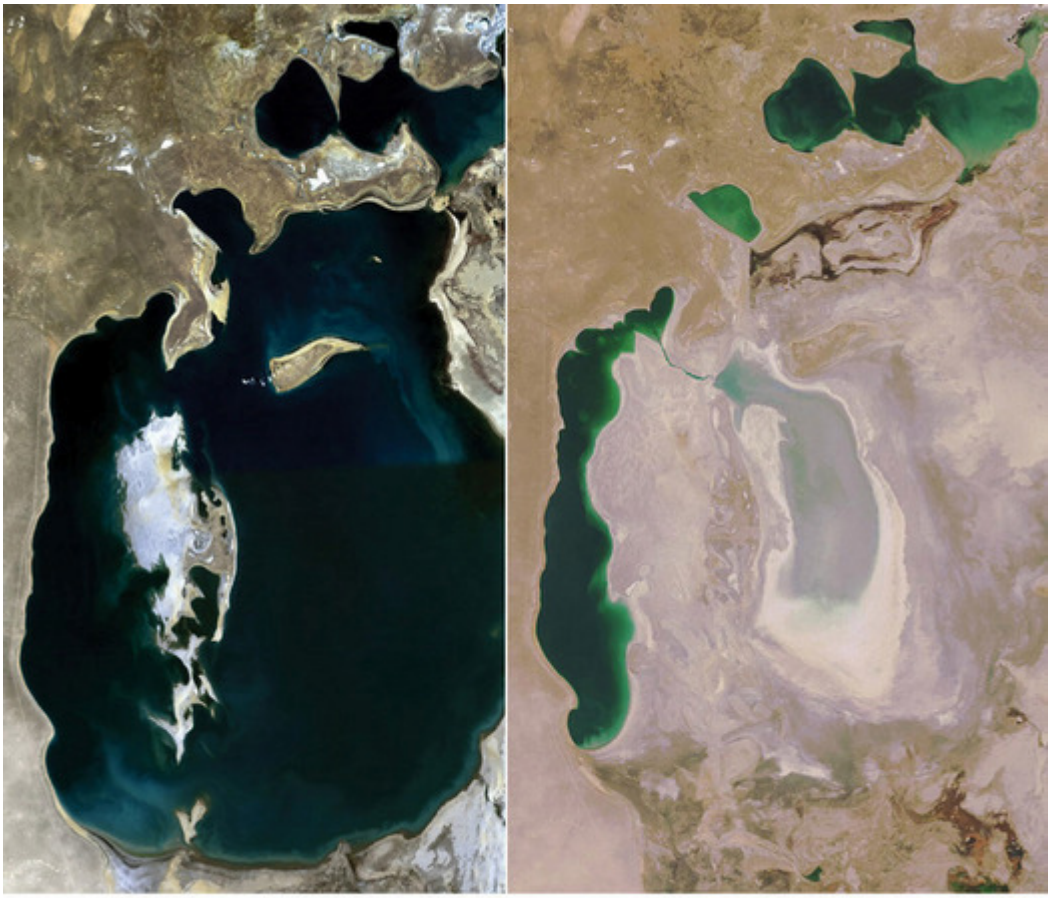
[54] Jason Clay, "Cleaner, Greener, Cotton," *AssetPanda.org,* 23 Oct 2007, http://assets.panda.org/downloads/cotton_for_printing_long_report.pdf. (accessed 16 Oct 2010)

[55] Fred Pearce, *Confessions of an Eco-Sinner: Tracking Down the Sources of My Stuff* (Boston: Beacon Press, 2008), 112.

[56] Ibid.

[57] Clay, "Cleaner, Greener, Cotton."

Figure 1
**The Dying Aral Sea Comparison of 1989 with 2008**




Source: McGuire, Kelly Ann, "While You Were Sleeping," *Chronogram*, 27 July 2009, http://www.chronogram.com/issue/2009/8/News+&+Politics/While-You-Were-Sleeping. (accessed 2 Dec 2010)

Unintended plants and animals are suffering the effects as well. In 1939, a Swiss chemist named Paul Müller created dichlorodiphenyltrichloroethane, or DDT, which became a highly effective base ingredient in pesticides that not only protected crops but also kept troops

alive in World War II by killing malaria-carrying mosquitoes and typhus-spreading lice.[58] Unfortunately, the compound was all too successful in exterminating pests, making many animals in its presence a 'collateral damage' target, unlike most other pesticides. In 1962, Rachel Carson published *Silent Spring,* exposing how DDT started at the beginning of the food chain and worked its way into animals and humans, which resulted in cancers, killed insects that are beneficial to agriculture, and also caused birds to lay eggs with shells that were too thin to survive.[59] Carson faced much criticism from the public and manufacturers, but her voice was heard when she was asked to testify in court, leading to the banning of DDT.[60]

Pesticides are also used for cosmetic purposes. Consumers, especially in developed countries, will pay higher prices for picture-perfect produce, requiring farmers to apply additional pesticides.[61] Due to the effects of the hazardous characteristics of pesticides, particularly when they are overused, the United States Department of Agriculture (USDA) created the Federal Insecticide, Fungicide, and Rodenticide Act of 1947, requiring manufacturers and distributors to obtain authorization to sell their products only to those who are certified to apply the chemicals.[62] This act was later revised in 1972, ensuring that current and future pesticides comply with stricter guidelines to protect workers by enforcing standards for less hazardous chemicals.[63] The European Commission also implemented the Agriculture Pesticides Directive 91/414 to protect both humans and the environment, requiring

---

[58] Taylor, "Pesticide Development."
[59] Natural Resources Defense Council, "The Story of Silent Spring," *NRDC.org,* 16 Apr 1997, http://www.nrdc.org/health/pesticides/hcarson.asp. (accessed 6 Oct 2010)
[60] Ibid.
[61] Pretty, "The Pesticide Detox," 5.
[62] Ibid., 6.
[63] Ibid

manufacturers to satisfy safety checks and submit the results to the European Food Safety Authority and member state regulators.[64] The large expense of performing these tests deterred many companies resulting in 360, or 60 percent, of the chemicals used in the pesticides to be withdrawn from the market by 2008.

The necessity for more sustainable agricultural processes has been apparent for decades. In 1992, United Nations Conference on Environment and Development (UNCED), comprised of 179 nations, gathered in Rio de Janeiro and signed Agenda 21, which outlined factors that need to be addressed to protect the environment in the 21st century, such as population growth, technology, effective uses for natural resources, and consumption.[65] Although the declaration has acted as a foundation for other programs, such as the UN Convention to Combat Desertification and the UN Fish Stocks Agreement, progress has not been effective overall, which may be due to the lack of enforcement for the signatories of Agenda 21 to fulfill their promises.[66]

In the meantime, farm workers and the environment continue to endure the chaos of the agriculture industry. There are 1.3 billion people relying on farming for their livelihoods.[67] Most of the farmers and farm workers are extremely poor and are frequently exploited.

---

[64] Pesticide Action Network, "EU Pesticides Clear Out," *pan-uk.org,* Sep 2002, http://www.pan-uk.org/pestnews/Issue/pn57/pn57p8.htm. (accessed 15 Oct 2010)
Ibid.

[65] Global Development Research Center, "Background to Local Agenda 21," 28 Sep 2010, http://www.gdrc.org/uem/la21/background.html. (accessed 15 Oct 2010)

[66] World Summit on Sustainable Development, "Progress Since the Earth Summit," *Johannesburg Summit,* 4 Sep 2002, http://www.johannesburgsummit.org/html/media_info/pressreleases_factsheets/wssd2_progress_rio.pdf. (accessed 15 Oct 2010)

[67] Michael Renner, Sean Sweeney and Jill Kibut, "Green Jobs: Towards Decent Work in a Sustainable, Low-Carbon World," *ILO.org,* Sep 2008, http://www.ilo.org/wcmsp5/groups/public/---dgreports/---dcomm/documents/publication/wcms_098503.pdf. (accessed 15 Oct 2010)

Pesticides need to be applied regularly. Although warnings are written on the containers with instructions to wear protective gear in order to prevent severe illnesses or death, many workers are illiterate or cannot spare the money for protective gear as it is usually not provided by the landowner. The health of only 5 percent of the world's agricultural workers is legally protected.[68] The climate in most of these regions is also uncomfortably hot and humid, making the use of protective gear unbearable. Pesticides will often require masks to protect the lungs and for all exposed skin to be covered and shielded from possible contact with the chemicals. Containers specifically designed for the distribution of pesticides are also encouraged. Still, shorts, T-shirts, sandals or barefoot, and liquid splashing out of unapproved containers onto the worker is the more typical state of affairs. Poisonings vary from long-term to acute with a loose estimate of 3 percent, or 25 million individuals, affected annually.[69] Forty thousand of those poisonings result in death.[70] A more precise estimate is not available since most cases are not reported as agricultural workers have no means to pay for medical assistance, and thus disregard the severity and stoically accept their fate.

Women and children can be affected by pesticides when working on farms that are freshly sprayed. However, those who do not work on farms can also become victims of accidental exposure. Many times, the only source of water to bathe and wash is a contaminated irrigation canal or stream. A breeze can also carry the mist of the spray to children playing outside the vicinity of the farm. Often, drinking water will be carried in re-used pesticide containers while other unmarked containers are used to carry or mix pesticides. In

[68] Ibid.
[69] Pretty, "Pesticide Detox," 25.
[70] Renner, "Green Jobs: Towards Decent Work in a Sustainable, Low-Carbon World."

one case, an 8-year-old boy was weeding in the fields with his parents. When he got thirsty he found an empty container to get water from a nearby ditch. Sadly, the container had been used for pesticides and the boy died before making it home.[71] There are countless tragic accidents such as this. Another documented case told of a father who consciously stored his clothes, that were wet from pesticides, outside on the roof to prevent his four children between the ages of six and eight from coming into contact with the chemicals. However, the rain at night washed the chemicals off his clothes and into the drinking water containers below. The children experienced headaches, nausea and convulsions after drinking the water and died later that day.[72] A study has shown that 97 percent of pesticides could be removed from the clothing if washed immediately, but since water is not always accessible to the workers, they risk further contamination.[73]

Pesticides are a $30 billion industry with 25 percent sold to Asian nations, where those living in poverty exceed 800 million.[74] Eighty percent of pesticides are used in developing countries where regulations are not as strict as there is no way of enforcing them.[75] Ninety-nine percent of all pesticide poisonings occur in developing countries.[76] These countries will frequently use pesticides that are too hazardous to pass the safety inspections in other countries, resulting in countries like Cambodia having 88 percent of their farmers experience pesticide poisoning due to 70 percent of their pesticide supply being classified by the World

[71] Environmental Justice Foundation, "Deadly Chemicals in Cotton," (accessed 15 Oct 2010)
[72] Ibid.
[73] Ibid.
[74] Marvin Levine, *Pesticides: A Time Bomb in Our Midst* (Westport: Preager, 2007), 226.
[75] Miles Livinoff and John Madeley, *50 Reasons to Buy Fair Trade* (Ann Arbor: Pluto Press, 2007), 91.
[76] Miles, *50 Reasons to Buy Fair Trade,* 91.

Health Organization (WHO) as "highly" or "extremely" hazardous.[77] There are also loopholes that the ten companies comprising 80 percent of the sales have discovered, such as shipping an unfinished product to developing countries and adding the main ingredient, which is unauthorized in the regulated countries, upon arrival.[78]

Pesticides can enter into the body through ingestion (many times workers do not wash their hands before eating as water is not available), inhalation, or absorbed through the skin, and since most farm workers and their families are poor, they are usually more susceptible due to a suppressed immune system from malnutrition and dehydration, especially children.[79] Symptoms of long-term and acute poisonings vary from vomiting, nausea, diarrhea, blurred vision, headaches, disorientation, confusion, unconsciousness and dizziness to coma, seizures, paralysis and death; or terminal illness such as a variety of cancers, lymphoma, leukemia, Alzheimer's, and Parkinson's disease.[80] Pregnant mothers who expose themselves to pesticides put their fetus at risk of stillbirth, low birth weight, spontaneous abortion, neonatal death, or birth defects.[81] There are alternative solutions that will be presented later in the paper to avoid these unfortunate mishaps.

---

[77] Sylviane Nguyen-Vaucheret, Dr Mike Shanahan, Juliette Williams and Steve Trent, "Death in Small Doses," *EJFoundation.org,* 2002, http://www.ejfoundation.org/pdf/death_in_small_doses.pdf. (accessed 16 Oct 2010)

[78] Ibid.

[79] FAO Newsroom, "Children Face Higher Risks from Pesticide Poisoning," *fao.org,* 5 Oct 2004, http://www.fao.org/newsroom/en/news/2004/51018/index.html. (accessed 16 Oct)

[80] Mike Shanahan, Claire Jordan, Steve Trent and Juliette Williams, "What's Your Poison," EJFoundation.org, 2003, http://www.ejfoundation.org/pdf/whats_your_poison.pdf. (accessed 16 Oct 2010)

[81] United Nations Environmental Programme, "Childhood Pesticide Poisoning," *UNEP Chemicals*, May 2004, http://www.chem.unep.ch/Publications/pdf/pestpoisoning.pdf. (accessed 16 Oct 2010)

Figure 2
**Effects of Pesticides When the Pregnant Mother is Exposed**

Source: Environmental Justice Foundation, "The Deadly Chemicals in Cotton," *EJFoundation.org,* 2007*,* http://www.ejfoundation.org/pdf/the_deadly_chemicals_in_cotton.pdf. (accessed 15 Oct 2010)

a. Note: Both girls were fetuses when their mothers were exposed to endosulfan pesticides in cotton fields. Eight months old girl suffering from hydrocephalus (left). Orphaned young girl with staghorn limbs (right).

## Genetically Modified Organisms

As the yields in developed countries have doubled or even tripled after World War II, the global number of tractors grew from 7 million to 28 million, which consequently increased farmers' overhead costs while decreasing the prices for their harvests since the farmers could now produce larger crops more efficiently.[82] Corn yields in the United States, for example, increased from 54.7 bushels per acre in 1960 to 154.3 bushels per acre in 2010.[83] In most

[82] Peter Pringle, *Food Inc.: Mendel to Monsanto – The Promises and Perils of Biotech Harvest* (New York: Simon & Schuster, 2003), 15.

[83] USDA "National Statistics for Corn," *USDA.gov,* 2010, http://quickstats.nass.usda.gov/results/AFBDFE1E-1AFC-35DE-8A93-7FB72F0DA089?pivot=short_desc. (accessed 20 Nov 2010)

cases, developing countries were unaffected by the biotech agriculture revolution since the farmers could not afford the expensive equipment or pesticides. This created a gap between these two worlds that grew 20-fold and only got bigger as biotech agriculture began in the 1980s, allowing for only the richer, developed countries to purchase the expensive genetically modified seeds that resist weeds or insects.[84]

In the mid 1800s, Gregory Mendel, a monk in Austria, began experimenting with traits of pea plants. He created several generations of hybrids over eight years and in 1866, and 28,000 pea plants later, he published his results.[85] He identified female and male reproduction organs to cross-pollinate plants for the desired traits of inheritance.[86] Although the significance of Mendel's discoveries was not realized until 16 years after his death, his work earned him the title "Father of Genetics".[87]

**Benefits -** Mendel's discoveries of manipulating plant characteristics set the stage for genetic engineering. Using a similar concept, genetically modified organisms (GMOs) were created, and continue to be improved, for the many benefits that they could offer with increased productivity, less human health issues, and reduced environmental impact. GMOs are designed to resist insects and weeds, requiring fewer pesticide and herbicide applications that have been known to poison the soil, land, animals, and humans, and throw off the balance of eco-systems. The reduced amount of pesticides depends on the type of crop. China, for

---

[84] Ibid.

[85] The Field Museum, "Gregor Mendel: Planting the Seeds of Genetics," *fieldmuseum.org,* 2007, http://www.fieldmuseum.org/mendel/story_pea.asp. (accessed 23 Oct 2010)

[86] Dennis O'Neil, "Mendel's Genetics," *Palomar.edu*, 7 Sep 2010, http://anthro.palomar.edu/mendel/mendel_1.htm. (accessed 23 Oct 2010)

[87] The Field Museum, "Gregor Mendel."

example, eliminated 156 million pounds, or the same amount that California uses each year, by planting genetically modified cotton seeds rather than conventional seeds.[88]

Certain genes could be added to the seeds that will provide additional nutrients that are especially beneficial to those who are malnourished in undeveloped countries, while also withstanding extreme weather conditions. Special traits can also be inserted into livestock that will allow for cattle to produce more milk for an increased source of protein.[89] The benefits of genetically modified crops have made them increasingly popular, given the rising demand on farmers for higher yields.

In 1996, there were 1.7 million hectares of GM crops globally, rising to 21 million hectares in 2004[90] and 134 million by 2009.[91] The leading GM-producing countries are the United States, Argentina, Brazil, Canada, and China, respectively.[92] Growth of GM crops has slowed in developed countries to 3 percent annually, or 2 million hectares, while developing countries are still increasing at 13 percent, or 7 million hectares, annually.[93] The year 2009

---

[88] Steve Kinsey, "Public Affairs – Passage of Marin County GMO Ban Would Encourage Widespread Use of Harsh Pesticides," *American Society of Plant Biologists,* 26 Oct 2004, http://www.aspb.org/publicaffairs/news/maringmo.cfm. (accessed 21 Oct 2010)

[89] FAO Newsroom, "Weighing the GMO Arguments: For," *fao.org,* Mar 2003, http://www.fao.org/english/newsroom/focus/2003/gmo7.htm. (accessed 21 Oct 2010)

[90] Elizabeth Smythe, *Corporate Power in Global Agrifood Governance* (Cambridge: MIT Press, 2009), 103.

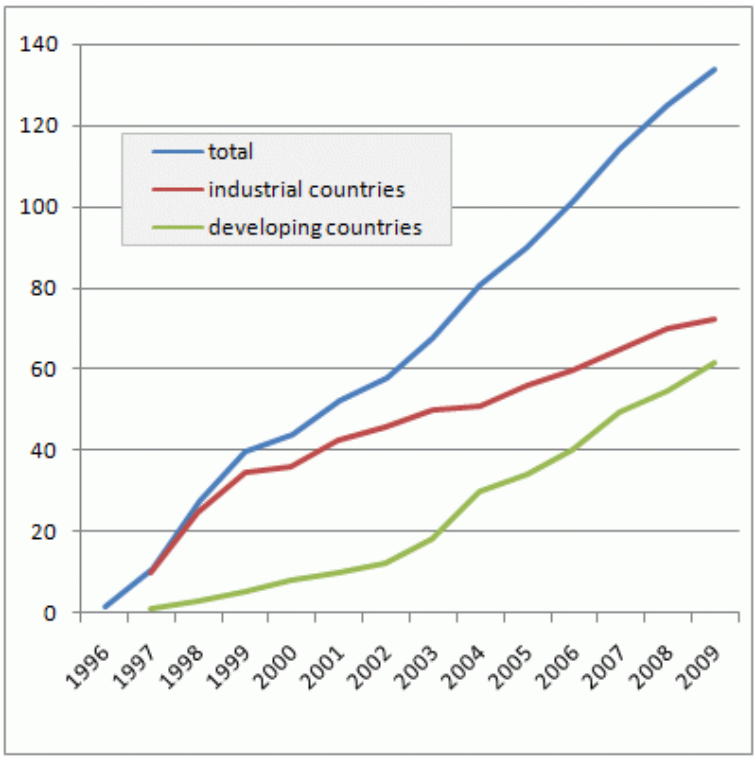
[91] GMO-Compass," Genetically Modified Plants: Global Cultivation on 134 Million Hectares," *gmo-compass.org,* 29 Mar 2010, http://www.gmo-compass.org/eng/agri_biotechnology/gmo_planting/257.global_gm_planting_2009.html. (accessed 25 Oct 2010)

[92] GMO-Compass, "Countries Growing GMOs," *gmo-compass.org,* 19 Jan 2007, http://www.gmo-compass.org/eng/agri_biotechnology/gmo_planting/142.countries_growing_gmos.html. (accessed 17 Nov 2010)

[93] GMO-Compass," Genetically Modified Plants: Global Cultivation on 134 Million Hectares."

witnessed the highest number of hectares with biotech crops, which may have been sparked by the food shortage in 2008.[94]

Figure 4
**Global Cultivation of Genetically Modified Plants in Millions of Hectares, 1996-2009.**




Source: GMO-Compass. "Genetically Modified Plants: Global Cultivation on 134 Million Hectares." *gmo-compass.org.* 29 Mar 2010. http://www.gmo-compass.org/eng/agri_biotechnology/ gmo_planting/ 257.global_gm_planting_2009.html. (accessed 25 Oct 2010)

Currently, there are projects underway to help benefit starving and malnourished individuals worldwide. Foods are being created to distribute the most nutrients in the small amount of foods that the poor can obtain. With the support of organizations like the Gates Foundation, research is being conducted to enrich or fortify foods (minerals and/or vitamins are

[94] International Service for the Acquisition of Agri-Biotech Applications, "ISAAA Brief 41-2009: Press Release," *ISAAA.org,* 23 Feb 2010, http://www.isaaa.org/resources/publications/briefs/41/pressrelease/default.asp. (18 Oct 2010)

added or increased in values) to reduce the number of children who are malnourished. In 1997, Andre Briend created Plumpy'nut, a peanut paste that is fortified with minerals and vitamins.[95] Doctor Mark Manary, a pediatrics professor whose goal is to eradicate malnutrition in African children, was the first to test the fortified peanut butter formula in his clinic in Malawi.[96] Due to the promising results, Manary started a franchise of Plumpy'nut, also known as Ready-to-Use Therapeutic Food (RUTF), which has a success rate of 89 percent when treating severely malnourished children.[97] The formula consists of ingredients from crops that are designed to be rich in protein and nutrients while also withstanding insects and disease.[98]

Manary now heads Global Harvest Alliance, a team of researchers who are creating other genetically modified crops for distribution to countries with the most malnourished children in order to provide them with their own sources of nutrient-rich and inexpensive foods.[99] BioCassava Plus is a project in which the alliance has invested $20 million since 1999.[100] Cassava is a staple food for a billion people in 105 countries, but it lacks sufficient nutrients due to the poor conditions where it is grown.[101] Over the next five years, researchers will plant trial fields of the genetically modified plants in Nigeria and Kenya.[102] These new

---

[95] Martin Enserik, "The Peanut Butter Debate," *Scienceemag.org,* 2 Oct 2008, http://www.validinternational.org/demo/reports/Science%20Article%20on%20RUF.pdf. (accessed 23 Oct 2010)

[96] Ibid.

[97] Rodney Southern, "Peanut Butter in Malawi Helping Hungry Children," *Associated Content*, 14 Sep 2007, http://www.associatedcontent.com/article/378593/peanut_butter_program_in_malawi_helping.html. (accessed 23 Oct 2010)

[98] Beth Miller, "Researchers Team Up to Battle Childhood Hunger," *wustl.edu,* 28 Jul 2009, http://news.wustl.edu/news/Pages/14394.aspx. (accessed 23 Oct 2010)

[99] Associated Press, " Scientists, Doctors Unite to Fight Malnutrition," *msnbs.msn.com*, 29 Jul 2009, http://www.msnbc.msn.com/id/32200926. (accessed 23 Oct 2009)

[100] Ibid.

[101] Danforth Center, "2009 Annual Report," *Danforthcenter.org,* 2009, http://www.danforthcenter.org/the_center/publications/annual_reports/default.asp. (accessed 23 Oct 2010)

[102] Ibid.

plants have tested to provide four times more iron, ten times more protein, and thirty times more beta-carotene.[103]

As demands upon agriculture continue to grow, the benefits that GMOs could offer become more apparent, as the table below illustrates:

Table 1
**Benefits of Genetically Modified Organisms**

| **Benefits** | |
|---|---|
| **Crops** | Enhanced taste and quality<br>Reduced maturation time<br>Increased nutrients, yields, and stress tolerance<br>Improved resistance to disease, pests, and herbicides<br>New products and growing techniques |
| **Animals** | Increased resistance, productivity, hardiness, and feed efficiency<br>Better yields of meat, eggs, and milk<br>Improved animal health and diagnostic methods |
| **Environment** | "Friendly" bio-herbicides and bio-insecticides<br>Conservation of soil, water, and energy<br>Bioprocessing for forestry products<br>Better natural waste management<br>More efficient processing |
| **Society** | Increased food security for growing populations |

Source: Human Genome Project Information, "Genetically Modified Foods and Organisms," *genetics.energy.gov,* 5 Nov 2008, http://www.ornl.gov/sci/techresources/Human_Genome/elsi/gmfood.shtml. (accessed 24 Oct 2010)

**Controversies** - Two German scientists were genuinely concerned about helping the poverty stricken in developing countries. Peter Beyer and Ingo Potrykus first created beta-carotene from daffodils and a bacterium which can be used as a replacement for vitamin A. Their goal was to infuse this substance into the small amount of rice that children eat in poor regions, with the hope of eradicating the vitamin A deficiency that causes blindness in 250,000

[103] Miller, "Researchers Team Up to Battle Childhood Hunger,"

to 500,000 children each year.[104] In 1999, after six years of experimentation, their creation of Golden Rice proved to be successful, insofar as they were able to produce rice rich in vitamin A.

Even though the extent of the benefits is immeasurable, the idea of GMOs continues to be the topic of many heated debates. For instance, harvesting tomatoes can be complicated since they are prone to rot during transit; but, as the tomato was the first genetically-modified food, it was a success since it did not spoil prior to arriving to its destination.[105] This interference with the natural genes of foods has caused concern among individuals of all disciplines, including farmers, scientists, doctors, and environmentalists. Many are worried that the corporations developing these seeds are consumed with the profit motive while disregarding the possibilities of causing allergies or accidentally creating "super" weeds or pests that could interrupt ecosystems.[106]

GMO critics are also concerned that manipulating the natural genetics of seeds could cause genes that do not offer immediate or overt benefits to be overlooked and disregarded, eventually to be replaced by genetic modifications. Traits that may be crucial for the survival in today's environmental conditions could be lost forever if seeds continue to be genetically altered. For instance, genes were recently discovered in wild soybeans that allow the plants to grow in extreme conditions of drought and salinization while offering protection against certain diseases.[107] These genes might not have been of importance previously, but with the

---

[104] George Ansstas, "Vitamin A Deficiency," *emedicine.com,* 12 Feb 2010, http://emedicine.medscape.com/article/126004-overview. (accessed 29 Nov 2010)

[105] Pringle, *Food Inc.: Mendel to Monsanto*., 15.

[106] Ibid., 16.

[107] Tan Ee, "Experts Find Lost Genes in Wild Soybean," *Reuters,* 15 Nov 2010, http://www.reuters.com/article/idUSTRE6AE16K20101115. (accessed 29 Nov 2010)

population explosion and change in climate patterns, these traits may be a source of food for families that would otherwise not be able to rely on any other crops.

Corporations that manufacture GMOs promise farmers that they can better protect their crops from insects and weeds while increasing their yields in less time. However, these advantages come at a high cost. Monsanto, one of the leading manufacturers of genetically modified seeds, instills hope in poor farmers of developing countries of leaving their lives of indebtedness by planting engineered seeds, as conventional seeds and pesticides have not shown any promise. However, the initial cost for the patented seeds is higher than for conventional seeds. Conventional seed prices increased by 63 percent in a 25-year period (1975-2000), while in just ten years the cost for genetically modified seeds increased by 230 percent.[108] Genetically engineered soybeans are almost twice as costly as conventional soybeans, while biotech corn seeds cost nearly seven times as much as conventional seeds.[109]

There are also stipulations to buying these genetically modified seeds. Besides the higher price, which allows the company to be paid royalties and "technology" fees for the research that went into these patented seeds, farmers have to agree to use the seeds once and then dispose of them rather than 'brown bagging,' or saving the seeds for the next harvest.[110] Anyone caught re-using seeds is subject to fines. Even farmers who do not purchase GM seeds are subject to penalties. If a conventional farmer's crops are contaminated by cross-pollination

[108] Charles Benbrook, "The Magnitude and Impacts of the Biotech and Organic Seed Price Premium," *organic-center.org,* Dec 2009, http://www.organic-center.org/reportfiles/Seeds_Final_11-30-09.pdf. (accessed 18 Oct)
[109] Ibid.
[110] Pietra Rivoli, *The Travels of a T-Shirt in a Global Economy* (John Wiley & Sons: Hoboken, 2009), 43.

from a neighboring GM field, the conventional farmer could be liable for fines.[111] Monsanto fully enforces these regulations and has collected over $15 million from farmers who intentionally or unintentionally had the patented seeds growing in their fields.[112] Often, farmers who believe they are innocent of the accusations of illegally growing GM seeds will settle outside of court, knowing that they cannot afford the legal fees they will incur from defending themselves against Monsanto.[113]

Many factors can affect the success of these expensive seeds. Weather is always an uncontrollable factor. A failed crop yield due to a lack or misunderstanding of the instructions on how to care for these genetically modified seeds and plants could be avoided; but, unfortunately, this does not always happen. Farmers are stretched beyond their means and are buried in mounting debt, with a good portion being spent on pesticides and herbicides. Millions fall deeper in debt to pay for the expensive genetically modified seeds, believing that they will eventually be free of their financial troubles as it will no longer be necessary to pay for pesticides and the crops will mature more quickly with higher yields. Unfortunately, insects and weeds can build immunity to these patented seeds, forcing the farmers to purchase additional pesticides to protect their costly crops.

Farmers are receiving more distressing news as studies show that GM seeds may actually underperform. In the United States, where 80 percent of cotton, soybean, and corn

---

[111] Alice Jaspersen, "Genetically Modified Crops Only a Fraction of Primary Global Crop Production," Worldwatch.org, 4 Dec 2008, http://www.worldwatch.org/node/5950. (accessed 25 Oct 2010)

[112] Stephanie Bernhardt, "High Plains Drifting: Wind-Blown Seeds and the Intellectual Property Implications of the GMO Revolution," *law.northwestern.edu,* 2005, http://www.law.northwestern.edu/journals/njtip/v4/n1/1/. (accessed 25 Oct 2010)

[113] Stephen Leahy, "Monsanto 'Seed Police' Scrutinize Farmers," *IPSnews.net,* 14 Jan 2005, http://ipsnews.net/interna.asp?idnews=27046. (accessed 25 Oct 2010)

are genetically engineered crops (see Appendix A),[114] reports have shown a 4 percent increase of pesticides on GM crops between the years of 1996 and 2004 and the number of "super weeds" or herbicide-resistant weeds have increased from two to fifteen.[115] Crops that are genetically designed to be resistant to weeds are now requiring additional herbicide protection that contains more toxic chemicals, since weeds have become immune to the less poisonous glyphosate.[116]

Some farmers, feeling that all avenues have been exhausted, resort to extreme measures. This is even more disturbing when whole villages rely on the success of these crops, allowing cases such as the following to occur:

> In December 2005, villagers of Dorli in Maharashtra state put up signboards announcing: "Dorli village is for sale." Each of the village's 270 residents, including all its children, was said to be carrying a debt of 30,000 rupees. Not long afterwards, the people of Chingapur village, also in Maharashtra, announced a "human market for the sale of kidneys" and sent invitations to India's President, Dr. Abdul Kalam, and Prime Minister Manmohan Singh to witness the proceedings. The villagers saw this as the only way to raise money to repay their debts.[117]

Farmer suicides occur throughout the world, but they have become a growing concern in the developing world. Many factors play a part in these tragedies, such as the increasing prices of seeds, pesticides, and fertilizers as the prices of crops decrease, leading to suicides of male farmers in the Midwest to double compared to the general population— one farmer per week in Britain, and one every 32 minutes in India.[118] More than 25,000 farmers have

---

[114] Jaspersen, "Genetically Modified Crops Only a Fraction of Primary Global Crop Production."

[115] Board of Agriculture and Natural Resources, *The Impact of Genetically Engineered Crops on Farm Sustainability in the United States* (Washington D.C.:The National Academies Press, 2010), 1.

[116] Board of Agriculture and Natural Resources, *The Impact of Genetically Engineered Crops,* 4.

[117] Litvinoff, 41.

[118] Srijit Mishra, "Indian Farmer Suicide," *UN.org,* 2007, http://www.un.org/esa/sustdev/csd/csd16/PF/presentations/farmers_relief.pdf. (accessed 25 Oct 2010)

committed suicide since 1997, often by drinking the very pesticides that were the source of their anguish.[119]

As new genetically-modified seeds are being created, many side effects have yet to be discovered and documented. Due to the uncertainty of GMOs, many countries have banned them, including the EU and Japan. In 2002, Southern Africa was experiencing drought and food shortages, affecting 26 percent of the population, or 14 million Africans.[120] The United States responded by sending half of the one million metric tons of food that was requested with GM corn. Malawi, Mozambique, Zimbabwe, and Zambia refused the aid, fearing the GM food might affect their regional crops, hinder future agricultural exports, and cause health problems.[121] The table below lists some of the concerns from critics regarding GMO crops.

Table 2
**Controversies Regarding Genetically Modified Organisms**

| **Controversies** | |
|---|---|
| **Safety** | Potential human health impacts, including allergens, transfer of antibiotic resistance markers, unknown effects<br>Potential environmental impacts, including: unintended transfer of transgenes through cross-pollination, unknown effects on other organisms (e.g., soil microbes), and loss of flora and fauna biodiversity |
| **Access and Intellectual Property** | Domination of world food production by a few companies increasing dependence on industrialized nations by developing countries<br>Foreign exploitation of natural resources |

[119] Chad Heeter, "Rough Cut," *PBS.org,* 26 Jul 2005, http://www.pbs.org/frontlineworld/rough/2005/07/seeds_of_suicid.html. (accessed 25 Oct 2010)
[120] Noah Zerbe, "Feeding the Famine? American Food Aid and the GMO Debate in Southern Africa," *Sciencedirect.com*, 2004, http://faculty.washington.edu/jhannah/geog270aut07/readings/GreenGeneRevolutions/Zerbe%20-%20GMOs%20in%20food%20aid.pdf. (accessed 25 Oct 2010)
[121] Ibid.

| | |
|---|---|
| **Ethics** | Violation of natural organisms' intrinsic values<br>Tampering with nature by mixing genes among species<br>Objections to consuming animal genes in plants and vice versa<br>Stress for animal |
| **Labelling** | Not mandatory in some countries (e.g., United States)<br>Mixing GM crops with non-GM products confounds labeling attempts |
| **Society** | New advances may be skewed to interests of rich countries |

Source: Human Genome Project Information, "Genetically Modified Foods and Organisms," *genetics.energy.gov,* 5 Nov 2008, http://www.ornl.gov/sci/techresources/Human_Genome/elsi/gmfood.shtml. (accessed 24 Oct 2010)

## Sustainable Options

Agricultural production has been able to keep up with the population growth rate, but poor distribution seems to be a key factor in malnutrition and starvation. Even though there is enough food to feed every person in the world, the current processes used to produce the food are not sustainable and will impede future production while the population continues to multiply. Every aspect of the food industry has to be evaluated to make processes efficient, including more sustainable farming techniques, better distribution, and the elimination of excessive waste.

A growing concern is the consumption of meat. The increasing demand for meat requires more land conversion to grow feed crops and grazing. As the middle class grows in developing countries, so does its disposable income, allowing for the purchase of more meat. In 1950, the United States produced 630 million chickens for meat consumption, but by the

year 2005 this number jumped to 8.7 billion.[122] Beef has the most detrimental effect on the environment compared to other meats since cattle releases significant amounts of greenhouse gases, as mentioned earlier. Also, 70 percent of all protein and calories that are consumed by livestock are fed to dairy and beef cattle.[123]

The production of livestock, consisting of feed production and land for grazing, accounts for 30 percent of the world's land.[124] Raising livestock requires a tremendous amount of resources and energy. Seventy-three percent of cereals produced in the U.S. are fed to livestock, compared to 37 percent globally, for meat consumption by mostly wealthy countries.[125]

Farmers rely heavily on pesticides to protect their crops from diseases, insects, and weeds. Unfortunately, the liquid is toxic and causes degradation in the quality of the soil, robbing it of the nutrients needed for the production of healthy and high yielding crops. Often, the chemicals are applied in excess resulting in avoidable damage. Farmers have options for reducing or even eliminating their dependence on pesticides and herbicides. Many farmers are turning to methods such as Integrated Pest Management (IPM) for the numerous benefits that the process offers, while still protecting their investments. IPM and other sustainable farming techniques provide alternative solutions utilizing natural pest control and fertilizers while

---

[122] Mark Hawthorne, "Feast of Famine: Meat Production and World Hunger," *American Chronicle,* 26 Nov 2010, http://www.americanchronicle.com/articles/view/71230. (accessed 26 Nov 2010)

[123] Bruce Dale, et al., "Economic, Environmental & Land Use Benefits of Animal Feed Co-Production with Cellulosic Biofuels," *Michigan State University,* 25 Aug 2008, http://www.mbi.org/_downloads/MBI_Symposium_Dale.pdf. (accessed 26 Nov 2010)

[124] Olivier de Schutter, "The Meatification of Diets and Global Food Security," *European Parliament,* 3 Dec 2009, http://www.europarl.europa.eu/climatechange/doc/speeche_Mr_de_schutter.pdf. (accessed 26 Nov 2010)

[125] Jules Pretty, "Can Ecological Agriculture Feed Nine Billion People?" *Monthly Review,* Nov 2009, http://monthlyreview.org/091123pretty.php#fn4b. (accessed 27 Nov 2010)

reducing land and water consumption. Often, the implementation of these methods provides more favorable results than conventional farming.

**IPM-** IPM entails using an eco-friendly approach for a long term strategy of lowering overhead costs, protecting the environment, people and the crops by combining traditional farming methods with today's technology. Farmers use natural methods of pest control by letting nature run its course as much as possible— let the good insects eliminate the bad insects, while using pesticides only when the crops are experiencing excessive damage. Pesticides usually have a target insect to eliminate; but at times, beneficial insects are also killed. This process puts the crops at risk of secondary pests, or insects that were not as much of a threat prior to the pesticide use but due to the primary target being eliminated, the secondary pests can now multiply freely. For example, one case involves apples sprayed with pesticides to kill the primary threatening insect, which was itself a predator species of the European red mite. Without its natural predator, a red mite infestation spread, resulting in farmers spending more money to buy additional pesticides to eliminate this unforeseen threat as well.[126]

Pests are responsible for 25 to 50 percent of crops losses in the pre- and post-harvest stages, resulting in farmers attempting to reduce these numbers by applying more pesticides, which continues the cycle of additional applications to combat resistance and secondary pests.[127] By studying the life-cycle and mating patterns of the target insects, farmers can be

---

[126] V.J. Shivankar, "Secondary Pest Resurgence," *Encyclopedia of Pest Management Vol 2,* 2007, http://www.crcnetbase.com/doi/abs/10.1201/9781420068467.ch155. (accessed 29 Oct 2010)

[127] United Nations, "Agenda 21," *UN.org*, 2009, http://www.un.org/esa/dsd/agenda21/res_agenda21_14.shtml. (accessed 29 Oct 2010)

better prepared to combat the pest cycle. Simple natural farming methods such as crop rotation and diversity could reduce the number of pests, insofar as a variety of plants attract many different insects that can prey on others to keep pest levels balanced.[128] Monocultures provide threatening insects with a continuous source of food while predatory insects may not be attracted to that certain crop. Cover crops, or crops that are planted for the purpose of protecting the main crop, attract beneficial insects by providing them with food and shelter while they prey on target insects. Cover crops could be clovers or rye in the winter, soybeans or velvet beans in the summer, and living mulch can be planted between the rows.[129] They also serve as protection against erosion while providing nutrients to the soil.[130]

Genetically modified seeds are also part of the IPM process. Seeds that are pest-resistant can cut down on pesticide use for healthier soil and, therefore, higher yields. In the mid-1990s, the European corn borer caused over one billion dollars in damage to North American corn crops, but pesticides were too expensive to apply on all of the crops and farmers could not treat only the affected areas since the damage was hidden. The first Bt (Bacillus thuringiensis) maize hybrid was enriched with protein that is poisonous to the pest. This genetically modified seed was released to the market in 1996, resulting in the reduction of European corn borers to a secondary pest status, allowing for half of the farmers to decrease their pesticide use.[131]

---

[128] Pretty, *Pesticide Detox,* 196.

[129] Preston Sullivan, "Overview of Cover Crops and Green Manures," *Appropriate Technology Transfer for Rural Areas,* Jul 2003, http://www.attra.org/attra-pub/PDF/covercrop.pdf. (accessed 29 Oct 2010)

[130] Washington State University, "Cover Crops and Beneficial Insects," *grant-adams.wsu.edu,* 2010, http://grant-adams.wsu.edu/agriculture/covercrops/benefits/beneficial_insects.htm. (accessed 29 Oct 2010)

[131] Michael Gray, Susan Ratcliffe, and Marlin Rice *(New York: Cambridge Press, 2009),* 31.

Also, the biological approach of introducing a predator to balance pests has proven to be successful. In the mid 1800s, the prickly pear cactus, which is found in the Americas, was introduced to Australia for its ability to attract scale insects that provides a reddish dye. Through the natural process of seed dispersion by the wind, animals, and rain, the cactus spread uncontrollably throughout Queensland and New South Wales and, by 1926, had taken over 24 million hectares while continuing to expand over one million more hectares each year. Every attempt to control the weed was a failure, forcing farmers to move from 12 million hectares that were deemed worthless. In 1927, the cactus moth was brought to the region for its ability to feed on and kill only prickly pear cacti. Millions of hectares were returned to the agricultural industry.[132]

**Organic-** The most natural and environmentally-friendly method of agriculture is using organic practices. Similar to IPM, organic farming techniques practice conservation and promote a balanced eco-system while using resources with little or no impact on the environment or its inhabitants. By reverting to time-honored farming techniques, crops and livestock are produced in what can be said to be their purest forms.

Organic agriculture does not permit the use of new technology, but instead uses proven methods relied upon over the centuries. Unlike IPM, organic crops do not use synthetic pesticides as a last resort, but rather natural pesticides such as the mixture of spices— for instance, cloves, thyme, rosemary, or mint with water. The solutions are successful in killing or repelling insects on strawberry, tomato, and spinach crops. These natural pesticides do not

[132] Ibid, 29.

need to be regulated; they are compatible with nature, and it is improbable that insects will develop a resistance.[133]

However, scientists are currently modifying the natural pesticides and herbicides for better effectiveness because there are significant disadvantages. For example, these liquids are not as potent and last only hours compared to synthetic pesticides that can be effective for up to several months.[134] Evaporation is also an issue, requiring excessive amounts to be applied. Some studies even show that these natural methods may be more detrimental to the environment compared with conventional pesticides. In one study, mineral oil and a fungicide were applied to soybean crops. The results demonstrated lower effectiveness than synthetic pesticides even with a large amount used, and the pesticides could not target the threatening insects, resulting in the elimination of the beneficial predatory insects as well.[135]

Besides natural pesticides, many organic farmers have experienced success by using *companion planting* to protect their crops. This technique entails planting grass or plants that will protect their main crop while also promoting healthier growth through diversity. One strategy of companion planting is the *push-pull* method. Farmers can pull destructive insects toward plants or grass that are more enticing than the cash crop while another plant pushes the insects out of the crops. For example, in eastern and central Africa, stem borers destroy maize by laying eggs in the plants. Scientists, knowing that they also like to lay eggs in elephant grass, plants the grass around the maize crops and *Desmodium* plants between the rows of

---

[133] American Chemical Society, " Killer Spices," *Science Daily*, 18 Aug 2009, http://www.sciencedaily.com/releases/2009/08/090816170910.htm. (accessed 1 Nov 2010)

[134] Ibid.

[135] Christine Bahlai, Yingen Xue, Cara McCreary, Arthur Schaafsma, Rebecca Hallett, "Organic Pesticides Not Always a 'Greener' Choice," *Science Daily,* 23 Jul 2010, http://www.sciencedaily.com/releases/2010/06/100622175510.htm. (accessed 1 Nov 2010)

maize, since the scent repels stem borers. Although farmers can use either the *push* or the *pull* method alone, there is more security in using them concurrently, and there are additional benefits such as soil protection and additional, healthier cattle feed.[136] The Desmodium plants are also effective against weeds by secreting a chemical from its roots that prevents the weeds from germinating.[137] This method has been highly successful, resulting in Kenyan farmers who have increased their yields from five bags at 90 kilograms each to 35 bags.[138]

Companion planting also includes attracting birds as another source of insect control. Farmers can make their land bird-friendly to those preying on insects that the farmers would like to eliminate. A Florida study shows that the majority of farmers surveyed, both conventional and organic, viewed birds as a good source of insect control and would like to do more to attract these predators.[139] Insect control can also occur at night. Depending on the region, studies have shown that bats prey on the same amount of insects at night as the birds do during the day.[140]

Table 3.
**Opinions of Conventional and Organic Farmers about Pest Control and Birds. (Survey based on responses from 50 conventional farmers and 26 organic farmers.)**

[136] Jennifer Pittet, "The Push-Pull Approach to Controlling Stem Borers in Maize," *farmradio.org,* Sep 2004, http://www.farmradio.org/english/radio-scripts/72-10script_en.asp. (accessed 1 Nov 2010)

[137] Tony Hooper, "Push-Pull: Using Plants as Natural Pesticides," *The Naked Scientists,* May 2008, http://www.thenakedscientists.com/HTML/content/interviews/interview/910/. (accessed 1 Nov 2010)

[138] Rothamsted Research, "How Companion Planting is Helping Over 3000 African Farmers," *BBRC.ac.uk,* 10 May 2005, http://www.rothamsted.bbsrc.ac.uk/Research/Centres/PressReleases.php?PRID=114. (accessed 2 Nov 2010)

[139] Susan Jacobson, Kathryn Sieving, Greg Jones, John McElroy, Mark Hostetler, Sarah Miller, "Farmers' Opinions about Bird Conservation and Pest Management on Organic and Conventional North Florida Farms," *ifas.ufl.edu,* Mar 2010, http://edis.ifas.ufl.edu/pdffiles/UW/UW16900.pdf. (accessed 2 Nov 2010)

[140] Kimberly Williams-Guillén, Ivette Perfecto, John Vandermeer, "Bats Limit Insects in a Neotropical Agroforestry System," *Science,* 4 Apr 2008, http://www.sciencemag.org/cgi/content/abstract/sci;320/5872/70?maxtoshow=&hits=10&RESULTFORMAT=&fulltext=bats+eat+as+many+insects+as+birds&searchid=1&FIRSTINDEX=0&resourcetype=HWCIT. (accessed 2 Nov 2010)

| | CONVENTIONAL FARMERS (%) | | | ORGANIC FARMERS (%) | | |
|---|---|---|---|---|---|---|
| **OPINIONS** | **Agree** | **Neutral** | **Disagree** | **Agree** | **Neutral** | **Disagree** |
| Pest control is an important issue for me.** | 100 | 0 | 0 | 73 | 8 | 19 |
| Insect pests cause considerable damage to my crops.** | 94 | 0 | 6 | 46 | 23 | 31 |
| I spend a considerable amount of money on pest control.** | 76 | 16 | 8 | 27 | 4 | 69 |
| I am satisfied with my current pest management strategies. | 74 | 14 | 12 | 62 | 15 | 23 |
| I consider leaf-eating insects a serious pest problem.** | 80 | 6 | 14 | 38 | 12 | 59 |
| I look for pests regularly. | 94 | 2 | 4 | 96 | 0 | 4 |
| I sometimes try new pest management strategies. | 64 | 12 | 24 | 81 | 0 | 19 |
| I think my current pest management strategies do not affect the environment. | 88 | 8 | 4 | 89 | 0 | 12 |
| If there were effective alternatives to using pesticides I would use them. | 90 | 6 | 4 | 92 | 4 | 4 |
| I would spend more money on pest management that might benefit the environment. | 76 | 18 | 6 | 88 | 4 | 8 |
| I recognize most of the different kinds of birds on my farm. | 94 | 2 | 4 | 96 | 0 | 4 |
| Birds cause damage to my crops. | 38 | 18 | 44 | 23 | 12 | 65 |
| Some birds do not cause damage to my crops. | 98 | 0 | 2 | 96 | 0 | 4 |
| I do not mind having birds on my farm that do not cause damage to crops. | 96 | 4 | 0 | 100 | 0 | 0 |
| Some birds eat only insects. | 90 | 8 | 2 | 81 | 19 | 0 |
| Birds could help lower insect populations on my farm. | 90 | 6 | 4 | 92 | 8 | 0 |
| I would like to attract birds to my farm if they lowered insect populations. | 84 | 10 | 6 | 100 | 0 | 0 |
| I think my farm provides good habitat for birds. | 92 | 4 | 4 | 96 | 4 | 0 |
| ** **indicates *significant* differences between conventional and organic farmers (from statistical tests)** | | | | | | |

Source: Susan Jacobson, Kathryn Sieving, Greg Jones, John McElroy, Mark Hostetler, Sarah Miller, March 2010, Institute of Food and Agricultural Sciences, University of Florida, http://edis.ifas.ufl.edu/pdffiles/UW/UW16900.pdf. (accessed 2 Nov 2010)

Organic processes require extensive regulations and documentation. In order to begin farming organically, the land has to undergo a three year transitional period to ensure any

toxins from pesticides are no longer contaminating the soil. The farmer has to demonstrate the processes they will use for pest control and production, along with maintaining detailed records, since they will be subjected to audits and annual inspections. Livestock are also raised naturally with no hormones or antibiotics, and they are provided access to the outdoors and organic feed. A third-party certification organization approves the product to be labeled as "organic".[141]

The number of organic farms is increasing as farmers globally are discovering the benefits and ability of their region to support organic methods. Australia, Argentina and China have the most organic agricultural land, while India, Uganda and Mexico have most organic producers.[142] Every year for the past ten years, sales of organic products continue to grow more than 20 percent.[143] Farmers are finding that organic production is profitable. There is normally a decrease in yields during the three-year transition, but once the organic processes are in place, the soil becomes nutrient rich again and yields are only five percent less than conventional; however, organic products sell for a premium price, more than making up for the difference. With the lower overhead costs and higher prices for organic produce, farmers can increase their profits by 37 percent. For example, a farm manager in Pennsylvania sold his organic corn in 2001 for $4.70 a bushel while conventional corn costs $2.10.[144] Farmers can also enjoy higher profits for organic milk. As with the transition for crops, production of organic

---

[141] USDA, "Organic Agriculture: Organic Certification," *usda.gov,* 30 Nov 2009, http://www.ers.usda.gov/Briefing/Organic/certification.htm. (accessed 2 Nov 2010)

[142] Organic-World Net, "The World of Organic Agriculture 2010 Yearbook," *Organic-World.net,* 3 Mar 2010, http://www.organic-world.net/470.html. (accessed 21 Nov 2010)

[143] Organic Farming Research Foundation, "Frequently Asked Questions about Organic Food and Farming," *ofrf.org,* 2008, http://ofrf.org/resources/organicfaqs.html. (accessed 2 Nov 2010)

[144] SARE, "Transitioning to Organic Farming," *NIFA USDA,* 2007, http://www.sare.org/publications/organic/organic.pdf. (accessed 2 Nov 2010)

milk can fall 10 to 15 percent but the income is much higher while costs for fertilizers, labor, and veterinary bills are cut.[145]

Table 4
**Organic and Conventional Prices for Field Crops 2000-2002**

| Produce | 2000 Organic | 2000 Conventional | 2001 Organic | 2001 Conventional | 2002 Organic | 2002 Conventional |
|---|---|---|---|---|---|---|
| Corn ($/bushel) | $3.51 | $1.86 | $3.01 | $1.89 | $3.96 | $2.13 |
| Soybean ($/bushel)* | $13.02 | $4.73 | $12.29 | $4.43 | $12.29 | $4.93 |
| Spring Wheat ($/bushel) | $5.72 | $2.82 | $5.75 | $2.96 | $5.54 | $3.47 |
| Oats ($/bushel) | $2.00 | $1.17 | $2.00 | $1.42 | $3.64 | $1.89 |

Source: SARE, "Transitioning to Organic Production," SARE.org, Jan 2007, http://www.sare.org/publications/organic/organic.pdf. (accessed 2 Nov 2010)

Note: *Cleared Hilum, cleaned
Prices paid to producers of crops grown organically in the Northern Plains and Upper Midwest

The question regarding organic foods having more nutritional value than conventional foods has been widely argued; however, there is not a consensus, with studies from various organizations providing contradictory results. One factor that researchers seem to agree on is that organic foods can be healthier since they contain less pesticide residue. But many consumers do not believe that the price of organic foods is worth the safety or environmental measures as organic foods can cost up to 30 percent more than conventional foods.[146] Prices remain higher for organic products, but the organic market will become more competitive as

[145] Ibid.
[146] Brian Dakss, "Organic Foods: Worth the Extra Costs?" *CBSNews.com,* 2 Apr 2007, http://www.cbsnews.com/stories/2007/04/02/earlyshow/contributors/emilysenay/main2636253.shtml. (accessed 20 Nov 2010)

large retailers such as Wal-Mart broaden their inventory to offer more organic items. Yet many organic farmers have valid concerns that the flood of organic products will drive the prices down and competition from large corporations will make small farmers struggle in order to stay in business.[147]

**Small and urban farming**- Unlike the United States, developing countries maintain millions of small farms. Technology has allowed for farms in developed countries to become highly efficient, making large farms relatively easy to manage. However, small farms are making a comeback. By 2007, farms in the United States with more than 50 acres decreased by 9 percent while those with less than 50 acres grew by 16 percent, for a total land increase of 46 percent.[148] Even though less than 2 percent of the U.S. population is engaged in farming, they have largely succeeded in feeding the remaining population, in addition to exporting their product.[149] Yet there are advantages of maintaining small farms that some farmers may find appealing, whether in a developed or undeveloped country.

Small farms do not usually use technologically advanced equipment but rather the use of hands-on tools which may require the labor emerging from the local community. Food is healthier and fresher as people can eat locally-grown products while also stimulating the local economy. Farmers are personally caring for their plants rather than a blanket process, using less pesticides and herbicides. The soil is able to support a variety of crops, allowing the small farm to be more productive overall, rather than the large farm that may be more productive for

[147] Pallavi Gogoi, "Wal-Mart's Organic Offensive," *Businessweek.com,* 29 Mar 2006, http://www.businessweek.com/bwdaily/dnflash/mar2006/nf20060329_6971.htm. (accessed 6 Nov 2010)

[148] SARE, "2010 SARE Report," *NIFA USDA,* 2010, http://www.sare.org/highlights/2010/2010Report.pdf. (accessed 2 Nov 2010)

[149] Daryll Ray, "Helping Developing Nations Improve Their Agriculture Requires Humility and Focus," *AgPolicy.org,* 30 Oct 2009, http://www.agpolicy.org/weekcol/483.html. (accessed 8 Nov 2010)

a certain crop. Small farmers are also more resourceful in using natural fertilizers, such as compost and manure, thus eliminating their dependence on fertilizers that can contribute to dead zones.[150]

Since small farmers have the freedom to choose their crops, some opt for native plants as they will take the least amount of care and resources. Indigenous crops also more reliably relate to the natural characteristics of the region, such as weather, insects and weeds. For example, Kenya is growing more pigeon peas, ambara nuts, and grains such as millet and sorghum. These crops can endure poor soil quality and little rain, unlike the maize yields that are decreasing due to the continuously changing weather patterns.[151]

The concept of small farms set the stage for a wave of urban farms that are increasing in popularity, providing one meal out of every five globally.[152] Utilizing small city plots and vacant buildings, city residents can increase their food security while cutting down on energy used to ship food to regions where the majority of the population lives. Urban farmers creatively implement non-traditional methods of utilizing resources. For example, a few organizations from in the Midwest are using abandoned buildings to produce not only fruits and vegetables but fish as well. The water from the fish tanks can be recycled as nutrients for the plants'

[150] Peter Rosset, "Small-Scale Farming: A Global Perspective – Benefits of Small Farms Greater than Those of Large Farms –Brief Article," *The Ecologist,* 8 Nov 2000, http://findarticles.com/p/articles/mi_m2465/is_4_30/ai_63699778/. (accessed 8 Nov 2010)

[151] Jeanne Roberts, "Kenyan Professor Promotes Indigenous Crops to Solve Africa's Food Crises," *WorldWatch.org,* 19 Aug 2010, http://www.worldwatch.org/node/6509. (accessed 8 Nov 2010)

[152] Fred Pearce, *Confessions of an Eco-Sinner* (Boston: Beacon Press, 2008), 237.

composted soil. This method of farming has also been taught in twenty orphanages worldwide so they can produce their own food.[153]

Agriculture that is carried out in buildings is called vertical farming. Rather than destroying more land for crops, farmers can use buildings to grow a different crop on each floor. Although some urban farmers already practice vertical farming, a building intended for the sole purpose of agricultural production has not yet been built. Due to the large amount of energy required, high-efficiency grow lights and renewable energy will need to be sourced. Critics argue that the substantial costs for the development of these buildings and the energy that they will require are not feasible for feeding a growing population. Designers are currently working on plans for glass buildings equipped with renewable resources with expectations that an 18-story building could feed 50,000 residents (see Appendix A).[154]

Professor Dickson Despommier from Columbia University stumbled upon the idea of vertical farming after his students calculated that 1,000 residents could be fed a 2,000 calorie diet by using 13 acres of rooftops to grow crops.[155] With an estimated 80 percent of the projected population of 9.5 billion people living in cities by 2050, vertical farming could save another 2.5 billion acres of land from being converted for agricultural use.[156] Hydroponics uses 70 percent less water than conventional agriculture, food prices will not be affected by the cost

---

[153] Karen Herzog, "Urban Farm in Racine is No Fish Tale," *JSonline.com,* 15 Jul 2010, http://www.jsonline.com/business/98569659.html. (accessed 8 Nov 2010)

[154] Bryn Nelson, "Could Vertical Farming be the Future?" *msnbc.com,* 12 Dec 2007, http://www.msnbc.msn.com/id/21154137/. (accessed 8 Nov 2010)

[155] Arnie Cooper, "Going Up? Vertical Farming in High-Rises Raises Hope," *Miller-McCune.com,* 19 May 2009, http://www.miller-mccune.com/science-environment/farming-in-high-rises-raises-hopes-3705/. (accessed 8 Nov 2010)

[156] Dickson Despommier, "Growing Skyscrapers: The Rise of Vertical Farms," *ScientificAmerican.com,* 16 Nov 2009, http://www.scientificamerican.com/article.cfm?id=the-rise-of-vertical-farms. (accessed 8 Nov 2010)

of fuel, as it was between 2005 and 2008 when prices almost doubled globally, and greenhouse gas emissions will be reduced.[157] Crops from vertical farming are also not susceptible to bad weather, therefore, eliminating this factor as a possible cause of food shortages.

**Distribution –** Many will argue that the number of individuals starving or suffering from extreme hunger is not due to a global shortage of food. Enough food exists to feed every person on earth a healthy diet of 2,800 calories a day. That number increases to a daily caloric intake of over 3,000 if grains were fed to humans rather than livestock.[158] Unfortunately, a simple re-evaluation of logistics and distribution is not the answer.

Developing countries comprise the majority of the global population, or over five of the six billion people, but not all of these countries are the victims of hunger as 80 percent of them are rapidly becoming industrialized.[159] Most of the remaining 20 percent are located in Africa and Central Asia, each facing obstacles that hinder their ability to emerge from extreme poverty.

It is arguable that providing foreign aid to alleviate starvation is futile. Trillions of dollars have been poured into these countries for decades, but the number of individuals going hungry everyday is steadily rising. For example, between 1992 and 2007, the number of undernourished sub-Saharan Africans increased by 53 percent, to 457 million.[160] Africa alone has received over $1 trillion in foreign aid in the past fifty years, but the annual growth rate is

[157] Ibid.
[158] Pearce, *Confessions of an Eco-Sinner*, 236.
[159] Paul Collier, *The Bottom Billion* (New York: Oxford, 2007), 1.
[160] Roger Thurow and Scott Kilman, *Enough* (New York: PublicAffairs, 2009), xiv.

minus 0.2 percent.[161] Foreign aid could be spent more effectively if the given country had a stable governmental or infrastructural foundation.

Of the more than one billion people who go hungry every day, 73 percent of them are experiencing or have recently experienced a civil war, resulting in a country to be 15 percent poorer after seven years of war and causing millions to go hungry as resources, including foreign aid, are misappropriated.[162] Thirty-eight percent of the billion are landlocked, making transportation of goods costly; and a poor country cannot rely on its neighbors, which typically face the same dilemma.[163] Another factor that can prevent the economic growth of a country is its government. Corrupt leaders can control natural resources and foreign aid, providing the opportunity for leaders in countries such as Nigeria and the former Zambia to pocket over $5 billion, resulting in $130 billion being misused.[164]

Distributing some of the surplus of food to these areas could complicate matters, especially if they fall into the hands of corrupt officials. Victims of hunger would not receive the food aid that was intended for them, and the officials could use it to fund their corruption or war. Aid can be effective by using alternative methods. The money that would be spent to transport food could be better used by teaching people how to feed themselves. Regions that experience drought and have nutrient-deficient soil could be taught how to rely on indigenous foods. Rather than giving officials money, foreign aid could be filtered through the NGOs or companies that will be educating the public to buy plots of land. There are several trusted

[161] Dambisa Moyo, *Dead Aid* (New York: Allen Lane, 2009), 46.
[162] Collier, *The Bottom Billion, 17, 27.*
[163] Ibid., 54.
[164] Moyo, *Dead Aid*, 52.

NGOs in these poor regions that are capable of providing guidance while also ensuring that corruption does not occur on these purchased plots for co-ops, without the repercussions of having funding pulled for the country.

**Waste-** On the other end of the spectrum, the number of overweight or obese individuals has a faster growth rate than those hungry or starving. There are currently 1.6 billion overweight adults (15 years or older), 400 million of them are obese (body mass index of 30 or greater) with projections of 2.3 billion overweight and more than 700 million obese adults by 2015.[165] Processed foods are partly to blame, since they are usually cheaper than healthy well-balanced meals and are easily accessible through fast food restaurants. Still, massive amounts of food are being wasted. As FAO calls for food production to double within the next forty years, excess amounts are being produced today but in the absence of efficient distribution, much of the surplus is simply wasted.

In 1995, the United States threw away 96.4 billion pounds of their 356 billion pounds of food supply.[166] The United States is by far the worst offender, and this disturbing trend continues to grow. Every year, Britain throws away 20 million tons of food, the United States disposes of 50 percent, and Japan's waste costs $101.6 billion.[167] Much of the food waste occurring in the developing world, though, is due to other uncontrollable factors. For example, 25 percent of Africa's crops are wasted due to infestation or bad weather, while up to 40

---

[165] World Health Organization, "Obesity and Overweight," *WHO.int,* Sep 2006, http://www.who.int/mediacentre/factsheets/fs311/en/. (10 Nov 2010)

[166] Andrew Martin, "One Country's Table Scraps, Another Country's Meal," *NYTimes.com,* 18 May 2008, http://www.nytimes.com/2008/05/18/weekinreview/18martin.html?_r=1&pagewanted=1&sq=food%20waste&st=cse&scp=3. (accessed 12 Nov 2010)

[167] Tristram Stuart, *Waste* (London: Penguin Books, 2009), xvi.

percent of crops globally are lost before they are harvested.[168] This is not the case for the excessive waste in developed countries. Just 5 percent of the food thrown out in the United States could feed 4 million people for a day.[169] Reducing food waste would be morally correct while also helping the economy and lessen the impact on the environment.

As more forests are being decimated for agriculture, much of the food being produced on these fields is ending up in landfills. Not only is this a waste of precious resources and energy, but the waste itself will then need to be transported to a landfill, where it will contribute to greenhouse gases. As mentioned earlier, methane gas does far more environmental damage than carbon dioxide. Only 2 percent of food is used as compost; the remaining waste ends up as landfill, whereupon it generates methane gas as it decomposes. This comprises 34 percent of the methane generated by the United States.[170]

Fortunately, there are several options to reduce waste. Besides producing less food, farmers globally could revert to the process of gleaning, which has been used for centuries. Individuals would gather food from fields that would otherwise be wasted as the crops have already been harvested mechanically or will not be harvested for economic reasons.[171] While the demand for food bank donations increases, the amount of donations has decreased with the slowing economy. Individuals could donate their excess food rather than wait for it to expire. Food scraps can also be used as animal feed or composted to enrich soil for healthier

---

[168] Stanford University, "Food Waste: From the Field to the Kitchen," *Stanford.edu,* 29 Apr 2009, http://stanford.edu/class/humbio129s/cgi-bin/blogs/economiclens/2009/04/29/food-waste-from-the-field-to-the-kitchen/. (accessed 12 Nov 2010)

[169] Rachel Oliver, "All About: Food Waste," *CNN.com/asia,* 22 Jan 2008, http://edition.cnn.com/2007/WORLD/asiapcf/09/24/food.leftovers/index.html#cnnSTCText. (accessed 12 Nov 2010)

[170] Ibid.

[171] University of Maine, "Food for Your Community: Gleaning and Sharing," *umext.maine.edu,* 14 Aug 2008, http://www.umext.maine.edu/onlinepubs/htmpubs/4301.htm. (accessed 12 Nov 2010)

crops. Countries such as Germany, Sweden, and Switzerland source gases from slaughterhouse wastes to help fuel their public transportation system, and they use a mixture of their food wastes, manure, and by-products from slaughterhouses to heat homes and generate electricity.[172]

## Solutions

The earth cannot sustain today's agricultural processes. As currently-available resources rapidly diminish, global population will continue to grow until the year 2050, when the rate will fall to 2.0 from the current average of 2.6.[173] Although birth rates in some developing countries are still high, women worldwide are having less children overall. Conventional farming already covers almost half of the earth's landmass and consumes nearly three fourths of fresh water supplies while polluting the land, air, and water and destroying much-needed biodiversity. Now FAO is projecting that the demand for production will double before 2050. [174]

Farming with the use of modern equipment, technologically advanced seeds, nutrient enriching fertilizers, and crop protection from pesticides and herbicides has made mass production efficient and highly profitable. But the constant increase in demand for higher yields per acre has caused fields to endure decades of monocultures and toxins that are dumped into the soil. Although farmers have been successful in using these practices, the land is now decreasing in productivity. Since 1961, productivity increased 2.3 percent each year but

---

[172] Stuart, *Waste*, 233.

[173] The Economist, "A Slow-Burning Fuse," *Economist.com,* 25 Jun 2009, http://www.economist.com/node/13888045. (accessed 12 Nov 2010)

[174] Daryll Ray, "Increase Agricultural Productivity is One Piece of a Complex Puzzle," *AgPolicy.org*, 23 Oct 2009, http://www.agpolicy.org/weekcol/482.html. (access 8 Nov 2010)

this growth has slowed and is expected to decrease unless more sustainable methods are used. Developing countries are also experiencing a slowing growth as their wheat yields have decreased from 5 percent to 2 percent and their maize and rice yields have both dropped by more than 2 percent.[175]

Many will argue that organic farming is a reliable or feasible method of feeding the growing population, but few will argue that the current processes are not damaging to the environment or do not pose a health risk. Even Dickson Despommier, the man who discovered vertical farming, believes that organic farming is not possible (unless indoors) due to the rate of climate change and the insufficient amount of arable soil that resists drought or flooding.[176] A standard agricultural process that can be applied to all farms globally does not exist, but there are different practices that are more sustainable and can be modified for maximum efficiency.

A variety of IPM methods could be used in several regions. Large-scale farming could benefit from IPM by planting GM seeds. It will produce the high yields needed while requiring less pesticide and herbicide use. Farmers can plan ahead to prevent future dependence upon chemicals to protect their harvests from infestation by planting companion crops that are appropriate for the type of produce and weather conditions, while cover crops could provide nutrients to enrich the soil.

Regions that endure extreme weather conditions would also benefit from IPM methods. GM seeds have been altered to not only withstand insects and weeds but also droughts and flooding, which is ideal for dry regions in Africa and wet areas in Asia. Integrating indigenous

[175] FAO, "Farming Must Change to Feed the World," *FAO.org,* 4 Feb 2009, http://www.fao.org/news/story/0/item/9962/icode/en/. (accessed 15 Nov 2010)

[176] Cooper, "Going Up? Vertical Farming in High-Rises Raises Hope."

foods with the main crops could provide variety and extra food security. Rising costs have caused a decrease in the amount of delivered food aid from the U.S. by more than 50 percent in the past six years.[177] Food aid could now be reduced to the extent that local villagers had the tools to be self-sufficient. Thus, more food could be produced, and those who are starving would not have to wait months for the food to be delivered and distributed.

Due to the large size of farms in the United States, IPM methods are feasible options. Organic farming would not be possible as it requires more care than conventional and IPM methods, and farmers are already having difficulties finding workers. Americans generally do not want to work on farms, regardless of the country's economic status, forcing farmers to hire foreign help— more than half of whom are illegal.[178] IPM methods would allow for farmers to continue mass production with a limited number of employees to care for the crops.

Small farms are typically more productive per acre than large farms due to the amount of care that is given to the crops. Intercropping, or planting secondary crops between the rows of the primary crop, and crop rotation with livestock provide more nutrients to the soil, resulting in over 200 percent more production per acre.[179] There is no consensus on the number of hectares that constitutes a small farm. The global average is 5.5 hectares, but 90

---

[177] Samuel Loewenberg, " Bush in Food Aid Fight with Congress," *Politico.com,* 6 Feb 2008, http://www.politico.com/news/stories/0208/8378_Page2.html. (accessed 15 Nov 2010)

[178] Garance Burke, "Americans Don't Want Farm Work Despite Economy," *HuffingtonPost.com,* 27 Sep 2010, http://www.huffingtonpost.com/2010/09/27/americans-dont-want-farmwork_n_740178.html. (accessed 15 Nov 2010)

[179] Peter Rosset, "The Multiple Functions and Benefits of Small Farm Agriculture in Context of Global Trade Negotiations," *Berkeley.edu,* 2000, http://bie.berkeley.edu/files/rosset-smallfarms.pdf. (accessed 15 Nov 2010)

percent of the farms in Asia are two hectares or less.[180] Two thirds of Africa's 33 million farms are less than two hectares, while 90 percent are less than ten hectares, and the average size of Latin American farms is 1.8 hectares.[181] However, in the United States, a farm with fifty hectares or less is considered small.[182]

As the majority of developing countries rely on small farms, converting them from conventional to organic farming would not be difficult. Organic farming has been successful in most regions, given enough farm workers to care for the crops. However, organic farming could be highly successful in tropical areas, too, where the land is rich in biodiversity and cover and companion crops could grow unhindered.

Conservation agriculture is a farming method that is similar to organic processes. It focuses on minimal mechanical tillage for maximum soil fertility with the continuous protection of cover crops. This in turn decreases the amount of erosion during the wet season and reduces the need for water by 30 percent during the dry season as the plants form deeper roots. Practiced on 100 million hectares globally, labor decreased by more than 50 percent as the need to fuel the mechanized equipment reduced by 70 percent. This method lessens greenhouse gas emissions by 30 percent.[183]

---

[180] FAO, "Asia and Pacific Commission on Agricultural Statistics," *FAO.org,* Apr 2010, http://www.fao.org/fileadmin/templates/ess/documents/meetings_and_workshops/APCAS23/documents_OCT10/APCAS-10-28_-Small_farmers.pdf. (accessed 15 Nov 2010)

[181] Miguel Altieiri, "Agroecology, Small Farms, and Food Sovereignty," *MonthlyReview.org*, Aug 2009, http://www.monthlyreview.org/090810altieri.php. (accessed 15 Nov 2010)

[182] Nigel Key and Michael Roberts, "Measures of Trends in Farm Size Tell Differing Stories," *USDA.gov,* Nov 2007, http://www.ers.usda.gov/AmberWaves/November07/DataFeature/. (accessed 15 Nov 2010)

[183] FAO, "Farming Must Change to Feed the World."

# Conclusion

There are countless options for making global agriculture more sustainable. Conserving resources and protecting agricultural workers are not solely the responsibilities of governments but of consumers as well. The demand for greener solutions often stems from consumers, who will urge governmental officials to reinforce measures. But this requires that consumers become more knowledgeable about the foods they bring home.

Simple steps such as eating locally could make a difference by supporting the local farmers and economy while also reducing carbon emissions. Given that the typical meal in the United States travels 1,500 miles before reaching the dinner table, buying locally could use four to seventeen times less fuel than conventional foods.[184] But not all local food is a greener option. Other factors have to be taken into consideration, since the seemingly obvious option is not always the best. The particular method of growing food can help determine if one should follow the rule of buying locally. For example, purchasing tomatoes in Sweden that were transported from Spain would release less carbon emissions than local tomatoes grown in a greenhouse using heat from fossil fuels.[185] Means of transportation should also be considered when making a purchase. Produce that is transported 1,000 miles by rail has a smaller carbon footprint than produce transported for 100 miles by truck.[186]

Reducing the amount of beef consumption could have a tremendous impact on lessening greenhouse gasses. When one considers that a cow and her calf emit more

---

[184] Sarah DeWeerdt, "Is Local Food Better?" *WorldWatch.org,* June 2008, http://www.worldwatch.org/node/6064. (accessed 16 Nov 2010)

[185] Ibid.

[186] Ibid.

greenhouse gasses in one year than a mid-size car driven 8,000 miles, a more eco-friendly meal option could consist of poultry or fish.[187] While 13 million hectares of forests are converted for agricultural use annually, 70 percent of all agricultural land globally is dedicated to livestock for grazing and feed production.[188] Opting for the occasional meal that included red meat would help reduce the demand for resources required to produce feed and also the need to clear more land for grazing.

Along with changing farming methods and buying locally, consumers will have to change their shopping and eating habits. Currently, most industrialized countries have access to foods aimed at satisfying our every craving. If the item is not in season, it can be shipped from anywhere in the world. Supporting sustainable agriculture would require that consumers alter their diets to include seasonal and indigenous foods. Local communities would benefit from employment opportunities, availability of fresh foods, and food security as they could grow and market their own food supply.

Converting land for agricultural use could have devastating effects by releasing greenhouse gases. But depending on the methods used, farming could help combat climate change. Organically farmed soybean and corn crops in the U.S. could store the same amount of carbon dioxide that would be released by driving round-trip from New York to Los Angeles over

[187] The World Watch Institute, *State of the World* (New York: W.W. Norton & Company, 2009), 40.
[188] FAO, "Climate Change and Food Security," *FAO.org,* Dec 2007, http://www.un.org/climatechange/pdfs/bali/fao-bali07-6.pdf. (accessed 16 Nov 2010)

116 million times.[189] This sequestered amount would also satisfy 73 percent of the Kyoto goal of carbon reduction for the United States if it was ratified.[190]

Companion, intercropping, and cover crops could absorb large amounts of carbon in the plants and soil. With minimal or no tillage, the gases stored in the soil will not be disturbed, preventing their release back into the atmosphere. The carbon- and nitrogen-rich soil can provide a third more soybeans and wheat compared to crops that are tilled, while decreasing soil erosion by up to 90 percent.[191] These crops also provide additional nutrients and allow for water to easily infiltrate for storage in the soil.

The benefits from utilizing more sustainable farming techniques represent a great improvement over current processes and practices. Converting to eco-friendly methods would be economically rewarding by saving on pesticides, herbicides, and fertilizers, with possible earnings from secondary crops by intercropping. Demanding premium prices from organic foods could help offset the additional cost of employing more farm workers and organic feed for livestock. Soil, animals, and water would be healthier by reducing or eliminating pesticides. Planting cover crops, such as legumes, would act as a fertilizer, reducing nitrogen runoff that causes dead zones while also providing a better source of cattle feed that is compatible with their digestion system to produce less methane.[192] The imminent danger of fresh water shortage could be prevented (only temporarily in some regions) since healthy soil has better absorption, requiring less water to be diverted for crop irrigation.

---

[189] Laura Sayre, "Organic Farming Combats Global Warming – Big Time," *Rodale Institute,* 10 Oct 2003, http://www.rodaleinstitute.org/ob_31. (accessed 26 Nov 2010)

[190] Ed Hamer, "10 Reasons Why Organic Can Feed the World," *The Ecologist,* March 2008, 44.

[191] The World Watch Institute, *State of the World,* 36.

[192] Hamer, "10 Reasons Why Organic Can Feed the World," 44.

Many studies have been performed worldwide to test the theory of supporting the population using sustainable farming methods. The outcome of these studies varies by region, but the results generally favor near-organic or organic processes, leading to the United Nations Environment Programme (UNEP) to release a report stating that organic practices may actually be the only way to obtain food security. In Africa, 114 farming projects in 24 different countries were conducted using more sustainable or organic processes. The yields were more than 100 percent of conventional chemical farming while also enduring drought conditions as the healthier soil retained more water.[193] Another study in 57 countries has demonstrated a 79 percent average yield increase on 286 farms using organic methods, which include crop rotations.[194] Yet an additional study of only developing countries showed results with two to three times the yield of industrial farming.[195]

Both conventional and sustainable farming methods could be debated with respect to their promise of feeding a growing population. Many believe that sustainable methods will not produce the yields necessary to feed all those in need. Considering the current overproduction of food, the amount of grain fed to livestock instead of humans, the large quantity of corn produced for ethanol, and the high percentage food being wasted, a 10 percent decrease in production will not affect the amount of food purchased in industrialized countries while the developing countries can finally have an opportunity to create their own food security as

---

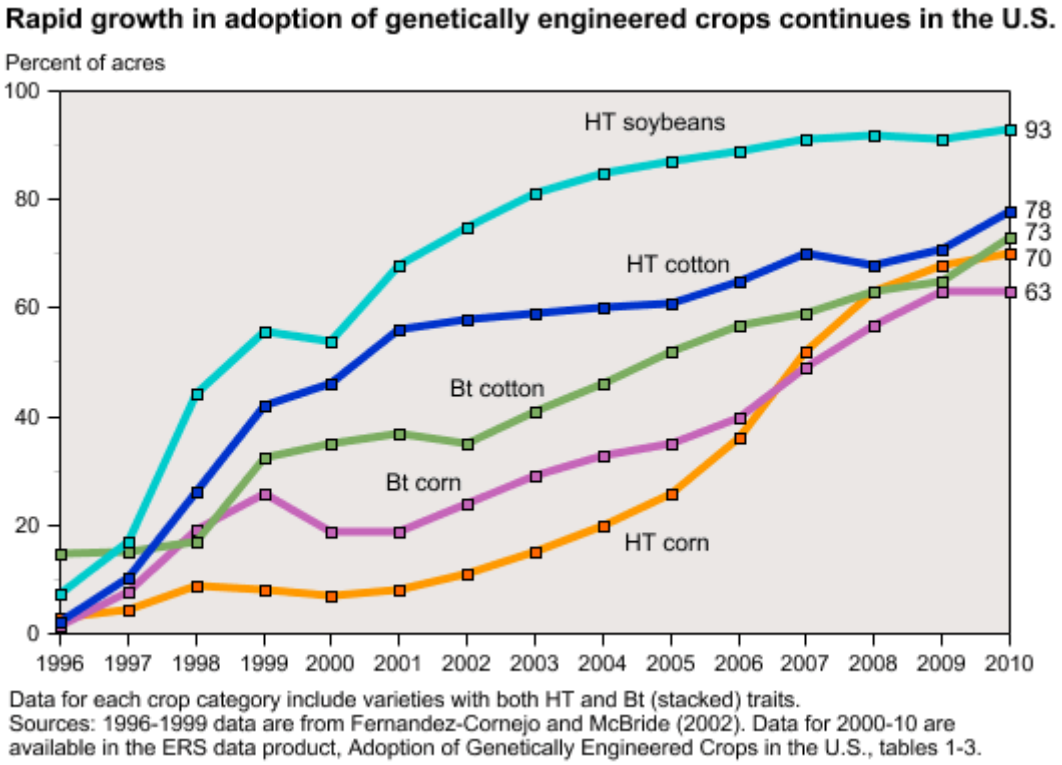
[193] Rodale Institute, "The Organic Green Revolution," *Rodale Institute,* 2008, http://www.rodaleinstitute.org/files/GreenRevUP.pdf. (29 Nov 2010)

[194] Jules Pretty, et al., "Resource-Conserving Agriculture Increases Yields in Developing Countries," *Environmental Science and Technology,* 21 Dec 2005, http://pubs.acs.org/doi/full/10.1021/es051670d. (accessed 29 Nov 2010)

[195] Rodale Institute, "The Organic Green Revolution."

conventional processes have not only failed to feed the masses, but are witnessing a downward trend in productivity. Some sustainable farming measures are more extreme than others, but implementing any of them will offer a chance at feeding 9.5 billion people in forty years while conserving valuable resources for future generations.

# Appendix A




Source: USDA, "Adoption of Genetically Engineered Crops in the U.S.," ers.usda.gov, Jul 2010, http://www.ers.usda.gov/Data/BiotechCrops/. (accessed 2 Dec 2010)

Note: (HT)Herbicide Tolerant; (Bt) Bacillus thuringiensis, protein used as an insecticide

# Appendix B


Source: Arnie Cooper, "Going Up? Vertical Farming in High-Rises Raises Hope," *Miller-McCune.com,* 19 May 2009, http://www.miller-mccune.com/science-environment/farming-in-high-rises-raises-hopes-3705/. (accessed 8 Nov 2010)

Note: Illustration of the crop possibilities vertical farm.

Source: Bryn Nelson, "Could Vertical Farming be the Future?" *msnbc.com,* 12 Dec 2007, http://www.msnbc.msn.com/id/21154137/. (accessed 8 Nov 2010)

Note: (Left) Designed by Gordon Graff, this concept of a vertical farm for downtown Toronto features 58 angled floors and 8 million square feet of growing space. (Right) Designed by Chris Jacobs, cylindrical towers outfitted with rooftop solar panels could be built as one unit or grouped in clusters to maximize food output.

# Bibliography


Achenbach, Joel. "A 'Dead Zone' in the Gulf of Mexico." *Washingtonpost.com.* 31 July 2008. http://www.washingtonpost.com/wp-dyn/content/story/2008/07/31/ST2008073100349.html?hpid=topnews.

"Agriculture." *GDFarm.info.* 2007. http://www.gdfarm.info.

Altieiri, Miguel. "Agroecology, Small Farms, and Food Sovereignty." *MonthlyReview.org*. Aug 2009. http://www.monthlyreview.org/090810altieri.php.

American Chemical Society. "Killer Spices." *Science Daily*. 18 Aug 2009. http://www.sciencedaily.com/releases/2009/08/090816170910.htm.

Ansstas, George. "Vitamin A Deficiency." *emedicine.com.* 12 Feb 2010. http://emedicine.medscape.com/article/126004-overview.

Associated Press. " Scientists, Doctors Unite to Fight Malnutrition." *msnbs.msn.com*. 29 Jul 2009. http://www.msnbc.msn.com/id/32200926.

Avery, John. "Malthus' Essay on the Principle of Population," *University of Copenhagen,* 31 May 2005, http://www.learndev.org/dl/MalthusEssay-Avery.pdf.

Bahlai, Christine, Yingen Xue, Cara McCreary, Arthur Schaafsma, Rebecca Hallett. "Organic Pesticides Not Always a 'Greener' Choice." *Science Daily.* 23 Jul 2010. http://www.sciencedaily.com/releases/2010/06/100622175510.htm.

Barrionuevo, Alexei. "Honeybees Vanish, Leaving Keepers in Peril." *New York Times,* 27 Feb 2007. http://www.nytimes.com/2007/02/27/business/27bees.html.

Benbrook, Charles. "The Magnitude and Impacts of the Biotech and Organic Seed Price Premium." *organic-center.org.* Dec 2009. http://www.organic-center.org/reportfiles/Seeds_Final_11-30-09.pdf.

Bernhardt, Stephanie. "High Plains Drifting: Wind-Blown Seeds and the Intellectual Property Implications of the GMO Revolution." *law.northwestern.edu.* 2005. http://www.law.northwestern.edu/journals/njtip/v4/n1/1/.

Burke, Garance. "Americans Don't Want Farm Work Despite Economy." *HuffingtonPost.com.* 27 Sep 2010. http://www.huffingtonpost.com/2010/09/27/americans-dont-want-farmwork_n_740178.html.

Butler, Rhett. "Tropical Rainforests: Disappearing Opportunities." 4 Oct 2010. http://rainforests.mongabay.com/0907.htm.

Board of Agriculture and Natural Resources. *The Impact of Genetically Engineered Crops on Farm Sustainability in the United States.* Washington D.C.:The National Academies Press, 2010.

Chapagain, A.K., et al. "The Water Footprint of Water Consumption*." UNESCO-IHE Institute for Water Education*. September 2005. http://www.waterfootprint.org/Reports/Report18.pdf.

Clay, Jason. "Cleaner, Greener, Cotton." *AssetPanda.org.* 23 Oct 2007. http://assets.panda.org/downloads/cotton_for_printing_long_report.pdf.

Collier, Paul. *The Bottom Billion.* New York: Oxford, 2007.

Cooper, Arnie. "Going Up? Vertical Farming in High-Rises Raises Hope." *Miller-McCune.com.* 19 May 2009. http://www.miller-mccune.com/science-environment/farming-in-high-rises-raises-hopes-3705/.

Curry, Matt and Betsy Blaney. "Borlaug, Who Saved Millions from Hunger, Dies." *USAToday.com.* 14 Sep 2009. http://www.usatoday.com/tech/science/2009-09-14-borlaug-obit_N.htm.

Dakss, Brian. "Organic Foods: Worth the Extra Costs?" *CBSNews.com.* 2 Apr 2007. http://www.cbsnews.com/stories/2007/04/02/earlyshow/contributors/emilysenay/main2636253.shtml.

Dale, Bruce, et al. "Economic, Environmental & Land Use Benefits of Animal Feed Co-Production with Cellulosic Biofuels." *Michigan State University.* 25 Aug 2008. http://www.mbi.org/_downloads/MBI_Symposium_Dale.pdf.

Danforth Center. "2009 Annual Report." *Danforthcenter.org.* 2009. http://www.danforthcenter.org/the_center/publications/annual_reports/default.asp.

De Schutter, Olivier. "The Meatification of Diets and Global Food Security." *European Parliament.* 3 Dec 2009. http://www.europarl.europa.eu/climatechange/doc/speeche_Mr_de_schutter.pdf.

Deen, Thalif. "U.N. Braces for a New Breed of Refugees." *IPS News*. 23 May 2007. http://ipsnews.net/news.asp?idnews=37860.

Despommier, Dickson. “Growing Skyscrapers: The Rise of Vertical Farms.” *ScientificAmerican.com.* 16 Nov 2009. http://www.scientificamerican.com/article.cfm?id=the-rise-of-vertical-farms.

DeWeerdt, Sarah. “Is Local Food Better?” *WorldWatch.org.* June 2008. http://www.worldwatch.org/node/6064.

Ee, Tan. “Experts Find Lost Genes in Wild Soybean.” *Reuters.* 15 Nov 2010. http://www.reuters.com/article/idUSTRE6AE16K20101115.

Enserik, Martin. “The Peanut Butter Debate.” *Scienceemag.org.* 2 Oct 2008. http://www.validinternational.org/demo/reports/Science%20Article%20on%20RUF.pdf.

Environmental Justice Foundation. ”The Deadly Chemicals in Cotton.” *EJFoundation.org.* 2007. http://www.ejfoundation.org/pdf/the_deadly_chemicals_in_cotton.pdf.

Elverland, Siri. “20 Million Climate Displaced in 2008.” *Norwegian Refugee Council.* 22 Sep 2009. http://www.nrc.no/?did=9429522.

FAO. “Asia and Pacific Commission on Agricultural Statistics.” *FAO.org.* Apr 2010. http://www.fao.org/fileadmin/templates/ess/documents/meetings_and_workshops/APCAS23/documents_OCT10/APCAS-10-28_-Small_farmers.pdf.

FAO. “Climate Change and Food Security.” *FAO.org.* Dec 2007. http://www.un.org/climatechange/pdfs/bali/fao-bali07-6.pdf.

FAO. “Economic Crisis is Devastating for the World’s Hungry.” *fao.org.* 14 Oct 2009. http://www.fao.org/news/story/0/item/36207/icode/en/.

FAO. “Farming Must Change to Feed the World.” *FAO.org.* 4 Feb 2009. http://www.fao.org/news/story/0/item/9962/icode/en/.

FAO. “ Hunger.” *FAO.org*. 2010. http://www.fao.org/hunger/hunger_graphics/en/.

FAO Newsroom. “Children Face Higher Risks from Pesticide Poisoning.” *fao.org.* 5 Oct 2004. http://www.fao.org/newsroom/en/news/2004/51018/index.html.

FAO Newsroom. ”Weighing the GMO Arguments: For.” *fao.org.* Mar 2003. http://www.fao.org/english/newsroom/focus/2003/gmo7.htm.

Foley, Jonathan. “The Other Inconvenient Truth: The Crisis in Global Land Use.” *Yale Environment 360.* 5 Oct 2009. http://e360.yale.edu/content/feature.msp?id=2196.

Gascoigne, Bamber. "History of the Domestication of Animals." *History World.* 2001. http://www.historyworld.net/wrldhis/PlainTextHistories.asp?groupid=1825&HistoryID=ab57&gtrack=pthc.

Gillis, Justin. "Norman Borlaug, Plant Scientist Who Fought Famine, Dies at 95." *NYTimes.com.* 13 Sep 2009. http://www.nytimes.com/2009/09/14/business/energy-environment/14borlaug.html?pagewanted=1&_r=1.

Global Development Research Center. "Background to Local Agenda 21." 28 Sep 2010. http://www.gdrc.org/uem/la21/background.html.

GMO-Compass. "Countries Growing GMOs." *gmo-compass.org.* 19 Jan 2007. http://www.gmo-compass.org/eng/agri_biotechnology/gmo_planting/142.countries_growing_gmos.html.

GMO-Compass. "Genetically Modified Plants: Global Cultivation on 134 Million Hectares." *gmo-compass.org.* 29 Mar 2010. http://www.gmo-compass.org/eng/agri_biotechnology/gmo_planting/257.global_gm_planting_2009.html.

Gogoi, Pallavi. "Wal-Mart's Organic Offensive." *Businessweek.com.* 29 Mar 2006. http://www.businessweek.com/bwdaily/dnflash/mar2006/nf20060329_6971.htm.

Gray, Michael, Susan Ratcliffe, and Marlin Rice. *New York: Cambridge Press, 2009*.

Gupta, Anil. "Origin of Agriculture and Domestication of Plants and Animals Linked to Early Holocene Climate Ameliorate." *Current Science.* 10 Jul 2004. http://www.ias.ac.in/currsci/jul102004/54.pdf.

Hamer, Ed. "10 Reasons Why Organic Can Feed the World." *The Ecologist.* March 2008. 44.

Hawthorne, Mark. "Feast of Famine: Meat Production and World Hunger." *American Chronicle.* 26 Nov 2010. http://www.americanchronicle.com/articles/view/71230.

Heeter, Chad. "Rough Cut." *PBS.org.* 26 Jul 2005. http://www.pbs.org/frontlineworld/rough/2005/07/seeds_of_suicid.html.

Herzog, Karen. "Urban Farm in Racine is No Fish Tale." *JSonline.com.* 15 Jul 2010. http://www.jsonline.com/business/98569659.html.

Holley, Joe and J.Y. Smith. "The Father of the Green Revolution." *WashingtonPost.com.* 14 Sep 2009. http://www.washingtonpost.com/wpdyn/content/article/2009/ 09/13/AR2009091300375.html.

Hooper, Tony. "Push-Pull: Using Plants as Natural Pesticides." *The Naked Scientists.* May 2008. http://www.thenakedscientists.com/HTML/content/interviews/interview/910/.

Hopwood, Nick and Jordan Cohen. "Greenhouse Gases and Society." *University of Michigan.* 29 Dec 2008. http://www.umich.edu/~gs265/society/greenhouse.htm.

Humphrey, John, John Olsen and Andrew Sherwood. *Greek and Roman Technology.* New York: Routledge, 1998.

International Service for the Acquisition of Agri-Biotech Applications. "ISAAA Brief 41-2009: Press Release." *ISAAA.org.* 23 Feb 2010. http://www.isaaa.org/resources/publications/briefs/41/pressrelease/default.asp

Jacobson, Susan, Kathryn Sieving, Greg Jones, John McElroy, Mark Hostetler, and Sarah Miller. "Farmers' Opinions about Bird Conservation and Pest Management on Organic and Conventional North Florida Farms." *ifas.ufl.edu.* Mar 2010. http://edis.ifas.ufl.edu/pdffiles/UW/UW16900.pdf.

Jaspersen, Alice. "Genetically Modified Crops Only a Fraction of Primary Global Crop Production." Worldwatch.org. 4 Dec 2008. http://www.worldwatch.org/node/5950.

Kaplan, Kim. "Honey Bees with Colony Collapse Disorder Show Their Genes." *USDA.* 24 Aug 2009. http://www.ars.usda.gov/is/pr/2009/090824.2.htm.

Key, Nigel and Michael Roberts. "Measures of Trends in Farm Size Tell Differing Stories." *USDA.gov.* Nov 2007. http://www.ers.usda.gov/AmberWaves/November07/DataFeature/.

Kinsey, Steve. "Public Affairs – Passage of Marin County GMO Ban Would Encourage Widespread Use of Harsh Pesticides." *American Society of Plant Biologists.* 26 Oct 2004. http://www.aspb.org/publicaffairs/news/maringmo.cfm.

Leahy, Stephen. "Monsanto 'Seed Police' Scrutinize Farmers." *IPSnews.net.* 14 Jan 2005. http://ipsnews.net/interna.asp?idnews=27046.

Levine, Marvin. *Pesticides: A Time Bomb in Our Midst.* Westport: Preager, 2007.

Livinoff, Miles and John Madeley. *50 Reasons to Buy Fair Trade.* Ann Arbor: Pluto Press, 2007.

Loewenberg, Samuel. " Bush in Food Aid Fight with Congress." *Politico.com.* 6 Feb 2008. http://www.politico.com/news/stories/0208/8378_Page2.html.

Lu, Peter. "World Hunger Dangers Exacerbated by Environment." *YaleHerald.com.* 19 Feb 2010. http://yaleherald.com/opinion/world-hunger-dangers-exacerbated-by-environment/.

Marshall, Jessica. "Grass-Fed Beef Has Bigger Carbon Footprint." *Discovery News.* 27 Jan 2010. http://news.discovery.com/earth/grass-fed-beef-grain.html.

Martin, Andrew. "One Country's Table Scraps, Another Country's Meal." *NYTimes.com.* 18 May 2008. http://www.nytimes.com/2008/05/18/weekinreview/18martin.html?_r=1&pagewanted=1&sq=food%20waste&st=cse&scp=3.

Matthews, Christopher. "Livestock a Major Threat to the Environment." *FAO Newsroom.* 29 Nov 2006. http://www.fao.org/newsroom/en/news/2006/1000448/index.html.

McKenna, Phil. "Measuring Corn Ethanol's Thirst for Water." *Technologyreview.com.* 14 Apr 2009. http://www.technologyreview.com/energy/22428/.

Miller, Beth. "Researchers Team Up to Battle Childhood Hunger." *wustl.edu.* 28 Jul 2009. http://news.wustl.edu/news/Pages/14394.aspx.

Mishra, Srijit. "Indian Farmer Suicide." *UN.org.* 2007. http://www.un.org/esa/sustdev/csd/csd16/PF/presentations/farmers_relief.pdf.

Moyo, Dambisa. *Dead Aid.* New York: Allen Lane, 2009.

"Natufian Culture." *Natufian.com*. 12 Jul 2010. http://www.natufian.com/.

Natural Resources Defense Council. "The Story of Silent Spring." *NRDC.org.* 16 Apr 1997. http://www.nrdc.org/health/pesticides/hcarson.asp.

Nelson, Bryn. "Could Vertical Farming be the Future?" *msnbc.com.* 12 Dec 2007. http://www.msnbc.msn.com/id/21154137/.

Nguyen-Vaucheret, Sylviane, Dr. Mike Shanahan, Juliette Williams and Steve Trent. "Death in Small Doses." *EJFoundation.org.* 2002. http://www.ejfoundation.org/ pdf/death_in_small_doses.pdf.

NOAA. "CSCOR Director Rob Magnien Discusses the Challenges of Using Biofuels to Produce Energy." *coastalscience.noaa.gov.* 15 Sep 2009. http://cc.bingj.com/cache.aspx?q= gulf+of+mexico+dead+zone+corn&d =4772005155897530&w=a8fac555,b534f5e

Office of National Statistics. "Population Estimates for UK, England, Wales, Scotland and North Ireland." *Statistics.gov.uk.* 30 Jun 2009. http://www.statistics.gov.uk/statbase/Product.asp?vlnk=15106.

Oliver, Rachel. "All About: Food Waste." *CNN.com/asia.* 22 Jan 2008. http://edition.cnn.com/2007/ WORLD/asiapcf/09/24/food.leftovers/index.html#cnnSTCText.

O'Neil, Dennis. "Mendel's Genetics." *Palomar.edu*. 7 Sep 2010. http://anthro.palomar.edu/mendel/mendel_1.htm.

Organic Farming Research Foundation. "Frequently Asked Questions about Organic Food and Farming." *ofrf.org.* 2008. http://ofrf.org/resources/organicfaqs.html.

Organic-World Net. "The World of Organic Agriculture 2010 Yearbook." *Organic-World.net.* 3 Mar 2010. http://www.organic-world.net/470.html.

Osteen, Craig and Merritt Padgitt. *Pesticides in Agriculture and the Environment.* New York: Marcel Dekker, 2002.

Owen, James. "Farming Claims Almost Half Earth's Land, New Map Shows." *National Geographic News.* 9 Dec 2005, http://news.nationalgeographic.com/ news/ 2005/12/1209_051209_crops_map.html.

Pearce, Fred. *Confessions of an Eco-Sinner: Tracking Down the Sources of My Stuff.* Boston: Beacon Press, 2008.

Pearce, Fred. *The Coming Population Crash.* Boston: Beacon Press, 2010.

Pesticide Action Network. "EU Pesticides Clear Out." *pan-uk.org.* Sep 2002. http://www.pan-uk.org/pestnews/Issue/pn57/pn57p8.htm.

Pittet, Jennifer. "The Push-Pull Approach to Controlling Stem Borers in Maize." *farmradio.org.* Sep 2004. http://www.farmradio.org/english/radio-scripts/72-10script_en.asp.

"Population Growth Rate." *CIA World Factbook.* 29 Sep 2010. https://www.cia.gov/library/publications/the-world-factbook/geos/xx.html.

Pretty, Jules. "Can Ecological Agriculture Feed Nine Billion People?" *Monthly Review.* Nov 2009. http://monthlyreview.org/091123pretty.php#fn4b.

Pretty, Jules. *The Pesticide Detox.* London: Earthscan. 2005.

Pretty, Jules, et al. "Resource-Conserving Agriculture Increases Yields in Developing Countries." *Environmental Science and Technology,* 21 Dec 2005, http://pubs.acs.org/doi/full/10.1021/es051670d.

Pringle, Peter. *Food Inc.: Mendel to Monsanto – The Promises and Perils of Biotech Harvest.* New York: Simon & Schuster, 2003.

Ray, Daryll. "Helping Developing Nations Improve Their Agriculture Requires Humility and Focus." *AgPolicy.org.* 30 Oct 2009. http://www.agpolicy.org/weekcol/483.html.

Ray, Daryll. "Increase Agricultural Productivity is One Piece of a Complex Puzzle." *AgPolicy.org*. 23 Oct 2009. http://www.agpolicy.org/weekcol/482.html.

Renner, Michael, Sean Sweeney and Jill Kibut. "Green Jobs: Towards Decent Work in a Sustainable, Low-Carbon World." *ILO.org.* Sep 2008. http://www.ilo.org/wcmsp5/groups/public/---dgreports/---dcomm/documents/publication/wcms_098503.pdf.

Rivoli, Pietra. *The Travels of a T-Shirt in a Global Economy.* Hoboken: John Wiley & Sons, 2009.

Roberts, Jeanne. "Kenyan Professor Promotes Indigenous Crops to Solve Africa's Food Crises." *WorldWatch.org.* 19 Aug 2010. http://www.worldwatch.org/node/6509.

Rodale Institute. "The Organic Green Revolution." *Rodale Institute.* 2008. http://www.rodaleinstitute.org/files/GreenRevUP.pdf.

Rosset, Peter. "Small-Scale Farming: A Global Perspective – Benefits of Small Farms Greater than Those of Large Farms –Brief Article." *The Ecologist.* 8 Nov 2000. http://findarticles.com/p/articles/mi_m2465/is_4_30/ai_63699778/.

Rosset, Peter. "The Multiple Functions and Benefits of Small Farm Agriculture in Context of Global Trade Negotiations." *Berkeley.edu.* 2000. http://bie.berkeley.edu/files/rosset-smallfarms.pdf.

Rothamsted Research. "How Companion Planting is Helping Over 3000 African Farmers." *BBRC.ac.uk.* 10 May 2005. http://www.rothamsted.bbsrc.ac.uk/Research/Centres/PressReleases.php?PRID=114.

SARE. "2010 SARE Report." *NIFA USDA.* 2010. http://www.sare.org/highlights/2010/2010Report.pdf.

SARE. "Transitioning to Organic Farming." *NIFA USDA.* 2007. http://www.sare.org/publications/organic/organic.pdf.

Sayre, Laura. "Organic Farming Combats Global Warming – Big Time." *Rodale Institute.* 10 Oct 2003. http://www.rodaleinstitute.org/ob_31.

Scheehle, Elizabeth, Dave Godwin, Deborah Ottinger and Benjamin DeAngelo. "Global Anthropogenic Non-CO2 Greenhouse Gas Emissions: 1990-2020." *EPA.gov.* June 2006. http://www.epa.gov/climate/climatechange/economics/pdfs/GreenhouseGasReport.pdf.

Shanahan, Mike, Claire Jordan, Steve Trent and Juliette Williams. "What's Your Poison." EJFoundation.org. 2003. http://www.ejfoundation.org/pdf/whats_your_poison.pdf.

Shivankar, V.J. "Secondary Pest Resurgence." *Encyclopedia of Pest Management Vol 2.* 2007. http://www.crcnetbase.com/doi/abs/10.1201/9781420068467.ch155.

Smythe, Elizabeth. *Corporate Power in Global Agrifood Governance.* Cambridge: MIT Press, 2009.

Southern, Rodney. "Peanut Butter in Malawi Helping Hungry Children." *Associated Content*. 14 Sep 2007. http://www.associatedcontent.com/article/378593/peanut_butter_program_in_malawi_helping.html.

Stanford University. "Food Waste: From the Field to the Kitchen." *Stanford.edu.* 29 Apr 2009. http://stanford.edu/class/humbio129s/cgi-bin/blogs/economiclens/2009/04/29/food-waste-from-the-field-to-the-kitchen/.

"Story of Farming." *History Link 101.* 2004. http://www.historylink101.com/lessons/farm-city/story-of-farming.htm.

Stuart, Tristram. *Waste.* London: Penguin Books, 2009.

Sullivan, Preston. "Overview of Cover Crops and Green Manures." *Appropriate Technology Transfer for Rural Areas.* Jul 2003. http://www.attra.org/attra-pub/PDF/covercrop.pdf.

Taylor, Eric., A. Gordon Holley and Melanie Kirk. "Pesticide Development: A Brief Look at History." *Southern Regional Extension Forestry.* Mar 2007. http://library.rawlingsforestry.com/sref/pesticide_development/sref-fm-010.pdf.

The Economist. "A Slow-Burning Fuse." *Economist.com.* 25 Jun 2009. http://www.economist.com/node/13888045.

The Field Museum. "Gregor Mendel: Planting the Seeds of Genetics." *fieldmuseum.org.* 2007. http://www.fieldmuseum.org/mendel/story_pea.asp.

The Worldwatch Institute. *State of the World 2007: Our Urban Future.* Washington, DC: Worldwatch Institute, 2007.

The World Watch Institute. *State of the World.* New York: W.W. Norton & Company, 2009.

Thurow, Roger and Scott Kilman. *Enough.* New York: PublicAffairs, 2009.

United Nations. "Agenda 21." *UN.org*. 2009. http://www.un.org/esa/dsd/agenda21/res_agenda21_14.shtml.

United Nations Environmental Programme. "Childhood Pesticide Poisoning." *UNEP Chemicals*. May 2004. http://www.chem.unep.ch/Publications/pdf/pestpoisoning.pdf.

University of Maine. "Food for Your Community: Gleaning and Sharing." *umext.maine.edu.* 14 Aug 2008. http://www.umext.maine.edu/onlinepubs/htmpubs/4301.htm.

University of Missouri. "Pesticides and the Environment." *University Extension.* Jul 1997. http://extension.missouri.edu/explorepdf/agguides/pests/G07520.pdf.

USDA. "Adoption of Genetically Engineered Crops in the U.S.," ers.usda.gov. Jul 2010, http://www.ers.usda.gov/Data/BiotechCrops/.

USDA. "Karnal Bunt: A Fungal Disease of Wheat." APHIS.USDA.gov. Jul 2001. http://www.invasive.org/publications/aphis/karnel.pdf.

USDA. "National Statistics for Corn." *USDA.gov.* 2010. http://quickstats.nass.usda.gov/results/AFBDFE1E-1AFC-35DE-8A93-7FB72F0DA089?pivot=short_desc.

USDA. "Organic Agriculture: Organic Certification." *usda.gov.* 30 Nov 2009. http://www.ers.usda.gov/Briefing/Organic/certification.htm.

Washington State University. "Cover Crops and Beneficial Insects." *grant-adams.wsu.edu.* 2010. http://grant-adams.wsu.edu/agriculture/covercrops/benefits/beneficial_insects.htm.

Wells, Spencer. Pandora's Seed. New York: Random House, 2010.

Williams-Guillén, Kimberly, Ivette Perfecto, and John Vandermeer. "Bats Limit Insects in a Neotropical Agroforestry System." *Science.* 4 Apr 2008. http://www.sciencemag.org/cgi/content/abstract/sci;320/5872/ 70?maxtoshow=&hits=10&RESULTFORMAT=&fulltext=bats+eat+as+many+insects+as+birds&searchid=1&FIRSTINDEX=0&resourcetype=HWCIT.

World Health Organization. "Obesity and Overweight." *WHO.int.* Sep 2006. http://www.who.int/mediacentre/factsheets/fs311/en/.

World Summit on Sustainable Development. "Progress Since the Earth Summit." *Johannesburg Summit.* 4 Sep 2002. http://www.johannesburgsummit.org/html/media_info/pressreleases_factsheets/wssd2_progress_rio.pdf.

Zerbe, Noah. “Feeding the Famine? American Food Aid and the GMO Debate in Southern Africa.” *Sciencedirect.com*. 2004. http://faculty.washington.edu/jhannah/geog270aut07/readings/ GreenGeneRevolutions/Zerbe%20-%20GMOs%20in%20food%20aid.pdf.