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The Agricultural Footprints on the Environment

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I am a second-semester freshman in Agricultural Biotechnology at the University of Kentucky. I am also a 2007 Governor's Scholar, a Senator Jeff Green Scholar, a College Board AP Scholar with Distinction, a UK Presidential Scholar, and a UK Chellgren Fellow. In addition, I am a recipient of the AMSTEMM Fellowship and am on the UK College of Agriculture Dean's List. In my spare time, I enjoy digitally manipulating photographs and occasionally writing poetry in order to transcribe some of my thoughts into a physical manifestation. I also like to bowl and have competed in both the United States Youth Bowling Congress and high school leagues.

My interest in the impact of agriculture on global warming is a direct result of my discussions with Dr. David Atwood, who instructed my first semester Discovery Seminar Program (DSP) class, "Energy and the Global Environment." Dr. Atwood was a constant source of encouragement for my writing. His lessons and research on climate change have provided me with a vast amount of information, along with the curiosity and yearning to delve deeper into this topic. I want to apply this knowledge to agriculture, because there seems to be a great deal of misunderstanding in this area with regard to the causes and preventability of climatic and environmental change. I believe that a collection and study of climate change research will help to dispel some of the misconceptions of the subject.

The knowledge and critical analysis skills that I have developed as a result of this experience will benefit me throughout my life and career. I am interested in becoming involved in scientific research, and in such a field I must be able to logically assess the studies that are presented in articles and journals. In the scientific community, it is important to not only be able to assimilate the information that is available on a subject, but also to critically evaluate and build upon it using prior knowledge.

Faculty Mentor: Professor David Atwood
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In "The Agricultural Footprints on the Environment," Philip Houtz points out several significant problems with Industrial Agriculture as it is now practiced around the world. The article will bring needed attention to this subject and, ideally, encourage appropriate changes. In particular, it is important that Industrial Agriculture evolve to address all of the new information being published on the negative consequences of current practices and strive for a more sustainable system of food production.

The Agricultural Footprints on the Environment

Abstract

Industrialized agricultural systems have given America a convenient and affordable means to supply a surplus of food products to its citizens. Transgenic technology, synthesized fertilizers, advanced pesticides, concentrated animal feeding operations (CAFOs), and the use of farm machinery have all contributed to humanity's ability to feed the world's rapidly growing population. However, the energy-intensive food operation of today may not be as ideal as we assume. Fossil fuels are burned to meet the energy requirements for the continual production of large quantities of fertilizer and to keep farm machines operational. Fertilizer and pesticide runoff from farmland ultimately drains into rivers that empty into estuaries and the oceans, where they contribute to hypoxia and weakening of competitive ability in aquatic animals. Indeed, there is some debate as to the necessity of industrial agricultural practices in light of the risks that have become associated with them after greater scrutiny. This article presents and analyzes information related to the consequences of agriculture on the long-term well-being of the global ecosystem, and addresses the sharp duality that has developed over this issue.

Introduction

Swift spikes in 2008 gas prices sparked a revitalized interest in the accessibility, efficiency, and stability of human energy sources. In order to move toward the utilization of more economical and environmentally friendly methods, we must take notice of discrepancies in all required large-scale, industrial operations — perhaps most importantly in agriculture, the activity that keeps everyone fed. Food is something that humanity in the developed world has come to take for granted. It is available, tasty, and generally nutritionally sound. No great amount of thought is generally attributed to the origin of our food, how it was grown and processed, or the amount of energy that was required for its transition to a commercial product and later transportation to easily accessible markets.

Great progress has been made in the United States in producing a surplus of food to feed the country. In the year 2000, the U.S. generated enough food to sustain every person in the country with 3,800 calories per day (Agriculture Factbook, 2008). The rate of food production in the U.S. has continued to rise as a result of improvements in transgenic crops, pesticide effectiveness, fertilizer use, farm machinery, limited agricultural species variety, and land management. However, this system comes at a cost. Processing and transporting food requires energy. This demand, achieved through the burning of fossil fuel resources, represents a large portion of energy use in the United States. Furthermore, the pesticides and fertilizers. which we depend on to optimize every crop harvest, wash off of fields and into streams and rivers and ultimately the oceans, where they can put ecosystems and human health at risk.

I will address the environmental costs of modern, industrialized agriculture due to greenhouse gas emissions and the application of both fertilizers and pesticides. I shall also compare this information with Dennis T. Avery's *Saving the Planet with Pesticides and Plastics*, which argues in favor of pesticide use, transgenic organisms, artificial fertilizers, fossil fuel energy, and free trade programs, and criticizes the positions of environmentalists and organic food activists. *Saving the Planet with Pesticides*, is an example of contemporary views in the defense of today's industrialized agricultural systems. In his book, Avery lays out multiple reasons why he believes that energy-intensive crop and livestock production will lead humanity to a more favorable future than the alternatives, which he sees as organic farming and innovative energy sources. His method of presentation consists of beginning each chapter with a series of statements from environmentalists and organic food activists, which he labels as a "mythmakers say" section. He then refutes these statements and ideas using outside data that he refers to as "reality says," as well as his own thoughts and opinions. As I will illustrate, Avery's sharp contrast of industrial vs. sustainable agriculture is biased and flawed in that it does not incorporate the latest scientific research and intentionally misrepresents sustainable agriculture.

Greenhouse Gas Emissions

The EPA (Environmental Protection Agency) has determined that the agricultural sector contributed approximately 6% of the total greenhouse gas emissions in the United States in 2007 (or roughly 413 million metric tons of CO_2 equivalents). This figure does not take into account the production of fertilizers and pesticides and the transportation of food goods, all of which require fossil fuels. Most agricultural greenhouse gas emissions are linked to meat production, in which energy is required to grow feed crops for the animals, transport feed and meat, manage the waste materials, and process the final product. Meat production accounts for 18% of all greenhouse gas emissions worldwide, according to data from the United Nations (Rosenthal, 2008). Although agriculture represents a small portion of the total greenhouse emissions of the United States, it is still an issue that must be addressed if the country is to reduce its total emissions. Standardizing the capture of methane (each molecule of which has approximately 25 times the heat trapping ability of a CO_2 molecule) from CAFOs and applying renewable energy sources to agriculture could decrease agriculture's impact on greenhouse gas emissions.

The most cited result of increased atmospheric greenhouse gas concentrations is an overall warming of the Earth. According to the predictions of the Intergovernmental Panel on Climate Change (IPCC), CO_2 concentrations in the atmosphere will reach 540-940ppm, with an associated temperature rise of 1.4-5.8°C by the year 2100 (IPCC, 1994). A global increase in temperatures of 2°C would hasten the melting of land-ice that has unexpectedly increased in the past few years. This unpredicted ice-loss is believed by some to be a result of the lubrication of the surface between the ice and the land beneath it with melt-water. Melting of land-ice in Greenland and Western Antarctica would produce a 0.34 meter rise in sea level; melting of sea-based ice could leave the world without a northern ice cap within 1-5 decades, which would represent loss of a barrier between nations in the northern hemisphere, the elimination of an arctic habitat, and a reduction in the Earth's albedo. This loss would further promote the warming of the planet (a synergistic warming trend known as the ice albedo positive feedback). The rise in sea level in response to the melting of land-ice could flood coastal regions, resulting in calamity for homes and infrastructure nearby. Despite the rise in sea level, associated with increased CO_2 concentrations, some still argue that global warming should not be a major concern.

In one particular chapter of *Saving the Planet with Pesticides and Plastics*, ("New Excuses for Bad Regulations"), Avery cites one of his articles from *American Outlook* to make the argument that we should not be concerned with global warming and have no reason to feel guilty regarding the continual consumption of fossil fuels as our primary energy source. In this article he claims that global warming would be a beneficial change for humanity because it might produce a climate similar to that of the Earth during the Medieval Climate Optimum, a period between 1000 and 1350 A.D. that experienced temperatures comparable to today's climate. That time period was particularly more habitable compared with the Little Ice Age that followed it (a period between 1400 and 1860 A.D. that experienced a 0.5°C global cooling) (Paleoclimatology, 2004).

Avery foresees a future in which a 1.6°C warmer climate and carbon dioxide concentrations of up to 550ppm spur plant growth and boost crop yields across the globe by 52%. Furthermore, Avery claims that alternative energy sources are harmful because they compete with traditional methods and increase energy prices, resulting in less money available for necessities (in particular, he mentions tractor fuel and the purchase of fertilizers). According to this information, humanity can benefit from a warmer, CO_2 saturated world, and should embrace this future rather than attempt to escape it through expensive, though novel, alternative sources of energy. However, increased atmospheric carbon dioxide concentrations will do more than simply warm the planet and raise sea levels.

Carbon dioxide in the atmosphere is taken up by the world's oceans in the form of bicarbonates that increase the overall acidity of the ocean. Ocean acidification poses a risk to many shellfish, coral, and plankton species that depend upon the ability to produce scleritized, calcium carbonate exoskeletons. The production of calcium carbonate is inhibited for some species under acidic environments, though studies have shown that a few species of coccolithophores display increased calcification under acidic conditions (Fabry, 2008). These species form the very foundation of the marine ecosystem food web and, thus, the loss of any one of these species would have a major impact upon the entire ocean environment. Dr. Michael Oppenheimer has stated that the impact of a 2°C warming by the end of the century would include extinction for up to 30% of all known species that are incapable of adapting fast enough to the environmental changes (Oppenheimer, 2008). I believe that humanity cannot risk the extinction of such a large number of organisms (especially when humanity is making such great accomplishments in the field of biotechnology, which depends upon the use of DNA from various organisms as a tool).

Another assertion of Avery's, which neglects to account for the price of biodiversity, is that wild-growth forests should not be preserved as refuges, but replaced with agriculturally controlled forest monocultures. He believes that these agriculturally monitored forests would improve management of lumber harvests, prevent unpredictable forest fires, and provide adequate habitation for a great variety of fauna and flora. Groups of old-growth trees would be cleared periodically to create habitation for organisms that require open areas, while at the same time removing dead wood, a potential source of forest fires. Some ancient trees would have to be kept however, in order to provide habitation to the organisms that use dead and dying trees. The creation of a systematic forest of only a desired tree species may extend the control of mankind further into the realm of nature and improve our ability to harvest resources. However, it should be noted that a forest of a single tree species may suffer a lack of biodiversity due to the fact that some wildlife depend on certain species of trees (or a variety of tree species) for survival.

Runoff Pollution

The application of fertilizers and pesticides on crop fields allows farmers to increase plant yields faster, and with less damage from pest species. However, excess pesticide and fertilizer residue is often washed into nearby surface and groundwater during rainfall, which transforms aquatic ecosystems — both freshwater and marine — into harmful environments. Pesticides can be toxic for a variety of organisms in waterways, but are especially harmful to arthropod life, which many pesticides are designed to target. Fertilizer runoff, on the other hand, promotes algal blooms in estuaries, where rivers meet the ocean, resulting in "dead zones."

Dead zones are oxygen-deficient areas that appear in the oceans, often close to the shores or near estuaries. These hypoxic zones occur when increased algae populations cause a greater amount of organic matter to be deposited into the oceans. This excess organic material is thus made available for decomposition through processes that consume oxygen, ultimately leaving the surrounding waters without sufficient oxygen to sustain fish and crustacean life. Hypoxia in the Chesapeake Bay has been much more severe in the past four decades than for the past 500-2,500 years (Phillips, 2007). The cause of algal blooms along the coasts of many countries is an increase in the amount of plant nutrients being carried by rivers into the oceans, which is ultimately a result of the addition of an excess of nitrogen and phosphorous fertilizers to croplands, where they later wash away into water systems. The algal blooms themselves may actually be beneficial in their ability to sequester atmospheric carbon dioxide, but they are also the source of the dead zones that have become an ever-growing problem facing the world's already strained fishing markets (EarthSave News, 2008). One solution to this problem is to encourage the use of the minimum amount of fertilizer required to achieve needed planet growth, because many modern farms apply an excess of fertilizer in order to ensure the desired yields.

Pesticides are another cause for concern among farm runoff components. Most pesticides are designed to protect crops from insect infestation and damage. These insecticides perform a much needed task in reducing crop losses due to insect damage, but they also kill aquatic arthropods, such as daphnia, when introduced into rivers or streams through runoff (Pereira, 2007). These small crustacean-like organisms are a vital source of food for the lower end of the aquatic food web; a decrease in their populations would result in a decline for many aquatic species. Other beneficial, predacious arthropods, such as dragonflies and damselflies, are also killed during their aquatic stages by insecticide runoff. Furthermore, modern pesticides are not readily degraded by many microorganisms, and thus have a particularly long lifespan in groundwater supplies and wells. Pesticides also contribute to a significant number of fish kills; an estimated 6-14 million out of 141 million total fish kills, between 1977 and 1987, have been attributed to pesticide contamination (Pimentel, 1992). Endocrine disrupting insecticides are of particular concern, due to their ability to alter the behavior of fish, and possibly human, populations directly.

Many organichloride compounds hinder the functionality of the endocrine system in target organisms. According to Sean Allen, a junior in Biology and Entomology at the University of Kentucky, research into the effects of endocrine disruptors, such as endosulfan and atrazine, upon aquatic ecosystems has shown that guppies and other fish may experience weakened competitiveness when exposed to such chemicals (Allen, 2008). This weakening decreases their chances of surviving and mating, thus producing a dampening effect on the population. Even small quantities of endosulfan can cause serious organ damage to humans if ingested, and is also able to be absorbed through the skin (Kucuker, 2009). There have been other studies that link endocrine disruptor exposure to pregnant women (from water supplies or other sources) with increased rates of autism in children (although these studies suggest that more research be done into the sensitivity of different gestation periods before a definite conclusion can be drawn) (Roberts, 2007). Animal testing, run by The Endocrine Society, has shown that there may also be a connection between endocrine disrupting chemical exposure and diabetes, and that it is reasonable to assume that these connections may also apply to humans, although, again, more research is required to be completely certain of the information. The Endocrine Society also noted that the mutations caused by endocrine disrupting compounds could occur in germline cells, which would then pass on mutations to any future offspring of the exposed individual (Diamanti-Kandarakis E. et al., 2009).

Avery defends the use of all pesticides, including endocrine disruptors and DDT, for keeping crops free of parasites and disease. He states that early studies of these pesticides could not find significant evidence of deleterious responses in exposed groups of wildlife or humans, and that studies relying on information from rat tests cannot be trusted for medical information. Avery criticizes the credibility of rat tests by bringing up the fact that the tests usually use extremely high doses, at which just about any chemical becomes toxic. Furthermore, the biological responses of rats to pesticides and other chemicals is not guaranteed to be the same as, or even similar to, a human response to the same stimuli.

Avery also points out the advancements that pesticides have made over the years. Farmers in industrialize countries now use machinery to apply pesticides safely as they move through the field, thus keeping themselves out of the way of the applied product. Some pesticides now come in a pelleted variety that is less prone to washing away (although the pellets may prove a hazard for birds that mistake them for seeds). Hence it can be said that the risk posed by pesticides toward humans directly is somewhat overstated due to flaws in the commonly used high-dose rat test and improvements that have been made in the delivery methods of modern pesticides.

Despite the advancements that we have made in applying pesticides, cases of water contamination and accidental poisonings have continued to be found in humans, as well as in natural ecosystems. It is estimated that 67,000 nonfatal poisonings, in the U.S. alone, are attributable to pesticides each year (Pimentel, 1992). It should be noted that endosulfan, an endocrine disruptor used as a broad-range insecticide, remains in use in the U.S. as an agricultural pesticide (although it is banned from other uses) to be applied on crops to prevent insect damage. I do not believe that we can continue to apply such chemicals so liberally when we know that they may be affecting not only the natural environment, through their attack upon organisms close to the base of the food chain, but also human lives.

Conclusion

Avery's *Saving the Planet with Pesticides and Plastics* is an intentional defense of modern agriculture that rationalizes the use of industrial farming techniques against alternative, sustainable agriculture techniques. However, Avery's arguments focus too strongly on denying any value in alternative farming techniques, to the point of making a number of claims that lack any scientific basis. Such an approach purposefully blinds both author and reader to truths that can be found only in seeking out and studying the enormous amount of trustworthy research that has been conducted and published in recent years. Threats to the sustained and greatly varied life of the planet must be taken seriously and assessed responsibly if we are to ensure that we do not create an unredeemable, catastrophic, global situation. Although the correct course of action remains unclear, it is certain that measures must be taken soon to ensure the protection of biodiversity on this world. The field of agriculture can help spearhead this movement by reducing its own impact upon the environment.

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Works Cited

Agriculture Factbook 2001-2002. 21, July 2008. USDA. (accessed 9 Dec. 2008) <http://www.usda.gov/factbook/chapter2.htm>

Allen, Sean. "Effects of Endocrine Disruption on Competitiveness of Male Guppies." UK AMSTEMM Biweekly Undergraduate Research Seminar. 5 Nov. 2008.

Avery, T. Dennis. *Saving the Planet with Pesticides and Plastic* (2nd Edition). Indianapolis, IN: Hudson Institute, Inc., 2000.

Dennis T. Avery. 2008. Hudson Institute. (accessed 19 Nov. 2008) <http://www.hudson.org/learn/index.cfm?fuseaction=staff_bio&eid=AverDenn>

Blaxill, Mark F. "What's Going On? The Question of Time Trends in Autism." *Public Health Reports*. 119.6 (2004): p536-551. (accessed 22 Nov. 2008) <http://web.ebscohost.com.ezproxy.uky.edu/ehost/detail?vid=1&hid=6&sid=16ad4333-8452-4933-9a9d-9bed3ec90807%40sessionmgr9&bdata=JnNpdGU9ZWhvc3QtbGl2ZSZzY29wZT1zaXRl#db=aph&AN=14938918>

Diamanti-Kandarakis, E., Jean-Pierre Bourguignon, Linda C. Giudice, Russ Hauser, Gail S. Prins, Ana M. Soto, R. Thomas Zoeller, and Andrea C. Gore. "Endocrine-Disrupting Chemicals: An Endocrine Society Scientific Statement." *Endocrine Reviews* 30.4 (2009): 293-342.

EarthSave News. "Ocean "Dead Zones" Becoming Global Problem." *EarthSave News*. 19.5 (2008): 1 continued on p. 10.

Fabry J. Victoria. "Marine Calcifiers in a High-CO¬2 Ocean." *Science*. Volume 320 (2008): 1020-1022. sciencemag.org.

Healy, Chrystal, Nichola J. Gotelli, and Catheine Potvin. "Partitioning the effects of biodiversity and environmental heterogeneity for productivity and mortality in a tropical tree plantation." *Journal of Ecology*. 96.5 (2008): p903-913. (accessed 19 Nov. 2008) <http://web.ebscohost.com/ehost/detail?vid=1&hid=9&sid=21b6617c-9a79-4b75-bebd-a92a11c37a19%40sessionmgr9&bdata=JnNpdGU9ZWhvc3QtbGl2ZSZzY29wZT1zaXRl#db=aph&AN=33654519>

IPCC. J.T. Houghton, L.G. Meira Filho, J. Bruce, Hoesung Lee, B.A. Callander, E. Haites, N. Harris and K. Maskell (Eds). *Climate Change, 1994: Radiative Forcing of Climate Change and An Evaluation of the IPCC IS92 Emission Scenarios*. Cambridge University Press, UK. (1994).

James C. Orr, Victoria J. Fabry, Olivier Aumont, Laurent Bopp, Scott C. Doney, Richard A. Feely, Anand Gnanadesikan, Nicolas Gruber, Akio Ishida, Fortunat Joos, Robert M. Key, Keith Lindsay, Ernst Maier-Reimer, Richard Matear, Patrick Monfray, Anne Mouchet, Raymond G. Najjar, Gian-Kasper Plattner, Keith B. Rodgers, Christopher L. Sabine, Jorge L. Sarmiento, Reiner Schlitzer, Richard D. Slater, Ian J. Totterdell, Marie-France Weirig, Yasuhiro Yamanaka, and Andrew Yool. "Anthropogenic Ocean Acidification Over the Twenty-First Century and its Impact on Calcifying Organisms." *Nature*. 437.25 (2005): 681-686. (accessed 18 Nov. 2008) <http://www.ipsl.jussieu.fr/~jomce/acidification/paper/Orr_OnlineNature04095.pdf>

Kucuker, Hudaverdi, Onder Sahin, Yücel Yavuz, and Yusuf Yürümez. "Fatal Acute Endosulfan Toxicity: A Case Report." *Basic & Clinical Pharmacology & Toxicology*. 104.1 (2009): p. 49-51. (accessed 4 Jan. 2008) <http://web.ebscohost.com.ezproxy.uky.edu/ehost/detail?vid=1&hid=116&sid=e84e89cc-8c7a-4ba1-ac8e-530cb0181cbc%40sessionmgr108&bdata=JnNpdGU9ZWhvc3QtbGl2ZSZzY29wZT1zaXRl#db=aph&AN=35771877>

Lewis, Robert G. “What Food Crisis?” *World Policy Journal*. 25.1 (2008): 29-35. (accessed 18 Nov. 2008) <http://web.ebscohost.com/ehost/pdf?vid=11&hid=16&sid=503359b3-3f58-4c21-b56a-0276e8557c1c%40SRCSM2>

Oppenheimer, Michael. “The Global Warming Challenge: Can Policy Catch Up with the Science?” Blazer Lecture Series 2008. University of Kentucky 16 Oct. 2008.

Paleoclimatology. 26 Oct. 2004. Page Paleontology Science Center. (accessed 2 Dec. 2008) <http://www.lakepoell.net/sciencecenter/paleoclimate.htm>

Pereira, Joana Luísa and Gonçalves, Fernando. “Effects of food availability on the acute and chronic toxicity of the insecticide methomyl to Daphnia spp.” *Science of the Total Environment*. 386.1-3 (2007):9-20. (accessed 31 Dec. 2008) <http://web.ebscohost.com.ezproxy.uky.edu/ehost/detail?vid=1&hid=106&sid=25aa19fd-ce82-4f9b-bfa1-d988eff37ca9%40sessionmgr103&bdata=JnNpdGU9ZWhvc3QtbGl2ZSZzY29wZT1zaXRl#db=aph&AN=26487055>

Phillips, S.W. ed. “Synthesis of U.S. Geological Survey Science for the Chesapeake Ecosystem and Implications for Environmental Management.” *U.S. Geological Survey Circular*. 1316, 63 (2007).

Pimentel, D., H. Acquay, et al. “The environmental and economic costs of pesticide use.” *BioScience*, 42.10 (1992): 750-760.

Roberts, Eric M., Paul B. English, Judith K. Grether, Gayle C. Windham, Lucia Somberg, and Craig Wolff. “Maternal Residence Near Agricultural Pesticide Applications and Autism Spectrum Disorders among Children in the California Central Valley.” *Environmental Health Perspectives*. 115.10 (2007): 1482-1489. (accessed 22 Nov. 2008) <http://web.ebscohost.com.ezproxy.uky.edu/ehost/detail?vid=1&hid=8&sid=0a28fa17-d827-4134-85ca-187d09b1a538%40SRCSM2&bdata=JnNpdGU9ZWhvc3QtbGl2ZSZzY29wZT1zaXRl#db=aph&AN=27024388>

Rosenthal, Elisabeth. “As More Eat Meat, a Bid to Cut Emissions.” *The New York Times*. (accessed 3 Dec. 2008) <http://www.nytimes.com/2008/12/04/science/earth/04meat.html?_r=3>

Seckler, David and Rock, T. Michael. “UN “Low” Projection of Population Growth Most Accurate.” *2020 Vision*. October 1997. International Food Policy Research Institute. (accessed 2 Dec. 2008) <http://www.ifpri.org/2020/NEWSLET/nv_1097/NV1097F.HTM>

U.S. and World Population Clocks. 3 Dec. 2008. U.S. Census Bureau. (accessed 3 Dec. 2008) <http://www.census.gov/main/www/popclock.html>

U.S. Greenhouse Gas Inventory. *April 2009*. U.S. Environmental Protection Agency. (accessed 23 Oct. 2009) <http://www.epa.gov/climatechange/emissions/usinventoryreport.htmll>

World Population to 2300. *2004*. United Nations: Department of Economic and Social Affairs, Population Division. (accessed 27 Nov. 2008) <http://www.un.org/esa/population/publications/longrange2/WorldPop2300final.pdf>

Zeebe E. Richard, James C. Zachos, Ken Caldeira, and Toby Tyrrell. “Carbon Emissions and Acidification.” *Science*. Volume 321 (2008): 51-52. sciencemag.org.

The Zimbabwe Guardian. “Kenya; Citizens Fighting Now Over Their Empty Stomachs.” Africa News. 1 June, 2008. (accessed 2 Dec. 2008) <http://www.lexisnexis.com/us/lnacademic/results/docview/docview.do?docLinkInd=true&risb=21_T5287786755&format=GNBFI&sort=RELEVANCE&startDocNo=1&resultsUrlKey=29_T5287786761&cisb=22_T5287786760&treeMax=true&treeWidth=0&csi=8320&docNo=9