

Spurring Sustainability: An Exploration of How Food Insecurity Forces Sustainable Metamorphosis

By Nick Hughes

Introduction

At times, the Environmental Studies can be a consistent lesson about a rather dire future our global society is steadily marching towards. Term after term, studies focus on our quite ubiquitous consumption and destruction of oceanic, terrestrial, and biological resources in a systematic, efficient manner. Intensive agriculture increases water conflicts, leeches vital nutrients out of the soil, and creates oceanic dead zones through nitrogen-rich runoff. Overfishing threatens fish stocks, while the freshwater found on (and underneath) land is diverted and utilized at alarming rates; some of which have already caused the depletion of water systems and even large seas. It becomes unmistakably clear that our methods of production and our societal inner-workings are unsustainable and need changing.

Last year, I began working as the Environmental Advocate with the University of Oregon's student government, the ASUO, and quickly learned just how small of a role sustainability played in important decision making and public policy. In the same way that big industries will curb pollution or environmentally damaging effects only to their sector's regulation standards, the ASUO would only commit to sustainability with a fervor that matched the standards set by the student community. An argument could easily be made that the U.S. government is the same way. Admitting to our dirty deeds and making a shift to a more sustainable society is a responsibility few want to shoulder. Perhaps no one wants to face the realities of becoming sustainable. The public prefers cheap, environmentally degrading energy, for instance, and the government is too content to shift its subsidization elsewhere and disturb the comfort of the status quo. Certainly, though, there must be pockets of cultures committed to sustainability for the the very purpose of being sustainable.

Two years ago, I volunteered on a self sustained eco-ranch called Rancho Margot in the Arenal region of Costa Rica. It was refreshing to experience a small community that understood the downfalls of our means of sustenance. I found comfort in the employment of closed loop systems to re-nourish cropland, sustainable management being applied to timber stands in order to provide the necessary furnishings for the ranch, and micro-hydroelectric generation fulfilling its energy demands. The land was seen as a dynamic provider that required adjusting to as much as it could be adjusted. A commitment to land stewardship and living within nature's

bounds existed more intensely than anywhere or anything I had ever experienced before.

Coming home, it was impossible not to notice the utter lack of such a mentality. There were movements in the right direction by various organizations and institutions; commitments to increasing levels of recycling, water conservation, and/or the distribution of organic produce. But these efforts were tainted by capitalistic motivations. Many would rather be *viewed* as an eco-friendly business than actually be one. Personal satisfaction and ethical motivation seemed to hold little ground against increasing profits through shifts in public perception. It can be, after all, cheaper to develop a new image than develop a new sustainable business model. I began to notice that holistic approaches to business and lifestyles which viewed sustainability as the bottom line, opposed to profit, were far and few between. Even more, those that did exist were often small endeavors dominated by the overwhelming and overbearing presence of big business and ever-expanding consumption. So the question arose: should there ever be a switch to the type of sustainable livelihood that I witnessed on Rancho Margot, what would be the pressures that would force it. If ethical inclination wouldn't produce it, and the public was disinclined to mandate it, what might the pressures be that initiate a switch to sustainability?

After the collapse of the Soviet Union, in 1990/91, the island-nation of Cuba had significant portions of their supply of food, fertilizers, and fuel cut off ^[1]. Caloric intake plummeted and the entire country was threatened with famine should it not act quickly. But it did. There formed an organization called the Cuba Organic Support Group, which promoted organic, sustainable farming techniques to be employed in both rural and urban landscapes. The movement quickly reshaped the food scheme on the island. Now known as the world's largest example of self sustained organic agriculture, Cuba serves as a case in which sustainable living systems were put in place on a massive scale through government intervention and widespread public support. But this was not done voluntarily, it was executed as a response to food shortages—out of necessity ^[2].

Necessity, or perhaps economic necessity, may just be the ultimate pressure that forces a sustainable metamorphosis. Just like in Cuba, food security could prove to be a catalyst to a sustainable revolution. It could be that food insecurity, which can include elements such as poor food distribution, volatile prices and water shortages, could bring rise to a much more sustainable way of life in various regions of the world. When the standard systems of production and distribution fail to meet the needs of various demographics, those groups will very likely see self sustained living as a viable alternative, or even a necessity. Similar to Cuba, a self sustained or at least non-damaging food regime could bring about a way of life that any environmental studies student or community member of Rancho Margot could appreciate. The food security of the future, or the potential lack thereof, may just bring about the more sustainable standard of living that we environmentalists seek.

But now, the question arises as to how food insecurity could arise and become a catalyst. To develop an image of how this might occur, food schemes can be analyzed and threats can be applied that might bring about food insecurity. This essay will explore the food schemes of two countries: Israel and Ethiopia. Potential environmental and political threats exist which may affect either of the two nations food production (or the production of the countries which supply their food). These threats will be applied and

extrapolated on various scales in terms of food production losses, price adjustments, and food insecurity. Finally, potential repercussions will be considered. In order to do this, food data from multiple institutions and governments will be used in conjunction with scientific literature focused on climate change, environmental degradation, and resource scarcities that might affect food production. These two literatures will be fused to produce a qualitative examination of vulnerabilities for both Ethiopia and Israel's food supply, access, and distribution.

Two Nations' Food

It is important to note that food data is difficult, if not impossible to ascertain with complete certainty. Even more, it is usually a year or two behind as it takes time for the totals from all sectors and harvests to be collected and assimilated onto one document. Nonetheless, the following data gives keen insight into the food schemes of Israel then Ethiopia. While Israel is highly developed, Ethiopia has been plagued by poverty and famine for decades, giving it a low human development index rating [3]. Both nations import food, but Israel's relatively small size and large population make it very dependent on production outside of its borders. Ethiopia generally produces most of the food its population consumes through small time farming. Through a deeper analysis, there forms a depiction as to how food insecurity may arise in two very different food systems.

Israel:

Israel serves as a compelling example of a country with a complicated food regime that is highly reliant on the provision of food from other countries. Its relatively small size and large, more developed population leads to a diverse diet richer in animal products than developing nations like Ethiopia, but still as equally reliant on staple commodities such as grains and cereals. Lets explore.

Israeli Diet and Consumption

Israel has a diet rich in vegetables, fruits, dairy products and grains and cereals. The Central Bureau of Statistics compiled a food supply balance sheet which serves as a consolidated data resource outlining the food products consumed by the general population. It essentially serves as a one stop shop for all data regarding the consumption and trade of food throughout Israel. Topping the list as the main suppliers of calories for the citizens of Israel are, in order, cereals and cereal products (33%), oils and fats (20%), and vegetables, fruit and potatoes (14%). Meat follows with 10% and milk and dairy products come next with 9% [21].

Protein supply is slightly different. Vegetables make up 51% of the protein supply, although for this statistic, cereals and cereal products are included in the vegetable figure, making up 33% of the 51% contribution. The other 49% of protein comes from live animal sources (29% from meat, 14% from milk and dairy products, 3% from fish, and 3% from eggs) [21]. So while grains, vegetables, and oils make up the

majority of the caloric intake, protein from animal products is vital to the Israeli diet as well.

Capacity to Grow and Sources of Food

What little wheat Israel does grow is entirely rain fed and are vulnerable to shifts in annual precipitation levels [4]. The nation's grain farmers can experience significant variations in production because of this, and given the very limited farmland to feed a population of almost 8 million, Israel is highly dependent on milling wheat and feed grain imports. In addition, their beef, dairy, poultry, and aquaculture industries are as dependent on these imports for feed grain as their citizens are for staple foods [4]. Wheat and corn are the main components and are sourced from Russia, Ukraine, and the United States in varying volumes. Along with these grains, Israel imports large quantities of milling wheat from the U.S., Russia, Hungary, and Canada. Soybeans are also imported as animal feed products, and originate mainly from the U.S., Paraguay, and Brazil. Feed grains make up roughly 74% of the total imports for these three major commodities, while milling wheat and soybeans account for 18 and 8 percent of the remaining total, respectively. In total, feed grains, milling wheat, and soybean imports amounted to 4.506 million tons for the 2013/14 market year. It is relevant to note that this quantity has grown by 1.7%, on average, every year since the 1998/99 market year; a growth rate nearly on par with Israel's rate of population growth (1.8% per year) [4].

The purchasing levels of each grain fluctuates based on pricing between the supplying nations. Some years favor growth in corn products, while others favor growth in feed wheat [4]. Corn byproducts from the U.S. have experienced growth in the last ten years, specifically Dried Distillers Grain (DDG) and Corn Gluten Feed (CCF); precariously enough, Israel has recently been recognized as one of the largest consumers of DDGS and CCF per capita. But although American DDGS and CCF has experienced growth in Israeli trade, U.S. feed grain has lost ground to the robust production in the Black Sea Basin. Israel sees this region as a more fitting supplier for feed grain due to its proximity and ability to send small and medium shipments. Ukraine and Russia are the main producers and exporters of grain in the Black Sea Basin [4].

Contrary to its heavy reliance on other nations for cereal and grain products, Israel is much more self sufficient when it comes to fruits, vegetables, and a variety of other horticultural crops. The Israeli Food Balance Supply Sheet reports only a 29% dependency on imports for their total fruit, vegetable, and potato consumption. This number jumps to 38% for oils and fats though. While these levels are much more comforting than their 97% dependency on bread and cereal imports, the quantities imported still represent a third of the total demand of the country. MIT's Observatory of Economic Complexity priced the total vegetable product imports into Israel by type, amounting to a noteworthy total of \$58.9 million dollars in 2011; \$27.8 million in processed vegetables, \$12.8 million in dried vegetables, \$11.9 million in frozen vegetables, and another \$6.4 million in assorted 'other vegetables' [5]. Unfortunately, the countries of origin were numerous and not traced in these totals. Oils and fats were just as difficult to track down countries of origin for. That being said, according to FAOSTAT data, edible oil imports totaled 83,472 tonnes in 2011, totaling some \$158.8 million [6]. Total vegetable imports for that same year were 29,903 tonnes, and fruit imports totaled 30,659 tonnes.

Threats to Food Security

DROUGHTS AND WATER SCARCITY

Already, Israel receives about 57.9% of its renewable water from outside its borders. That being said, the FAO's Aquastat online database on everything water cites 57.9% as a constant for over a decade [7]. While Israeli surface and groundwater is recharging at a rate of 750 million cubic meters per year, the total amount of water withdrawn per year has stood above 1.8 billion cubic meters since before 1987 (recent estimates place it around 1.954 billion cubic meters)[8]. A clearly unsustainable trend emerges, becoming more transparent when looking at the renewable water available per capita, which has declined steadily since the 60's. It currently stands at 99.2 cubic meters per person per year, only about 60% of what it stood at in 1992, the year I was born [9].

All this being said, Israel has done extremely well in increasing water efficiency. The nation now produces \$90.5 per cubic meter of freshwater withdrawn; a number that is over double the \$43.5 produced with every cubic meter consumed in 1992. While this is a wonderful feat, the issue remains that Israel's food production levels are extremely vulnerable to water shortages. For instance, using data from Israel's Central Bureau of Statistics, average prices of February tomatoes were 33% higher during the 8 year drought between 2005 and 2012[10] as compared to the prices from 1996-2004. January cucumbers were 59.7% higher. March lettuce prices were 30.9% higher, and February apple prices were 14% higher[11]. The World Bank estimates that Israel had about 28% of their agricultural land irrigated in 2009. The remainder relies on consistent rains [12].

Based on predictions by NOAA, Israel can expect to see a decrease in annual rainfall of 1-2 inches by the end of the 21st century. Another study suggests that the rainy season will be shortened and the distribution of rainfall will adjust from region to region. Specifically, the boundary between the arid southeast and the wetter northwest will retreat northward, reducing the overall size of sufficiently rain-fed land. Volatility of rainfall patterns were also predicted to intensify due to rising global temperatures [13]. This leaves the productivity of Israel's agricultural sector in a precarious situation as it moves into the future.

Not just domestic production is threatened though. Nearly the entirety of their grain supply is being sourced from the U.S., Ukraine, and Russia, regions which are also expected to experience shifts in rainfall patterns and higher volatility. This could greatly affect the price of Israel's staple food as well as that which feeds their massive meat and animal product economy: grain. To the right is a map from the EPA outlining the expected rainfall changes in the U.S.'s breadbasket, the great plains. The two on the following page show where corn and Red Winter

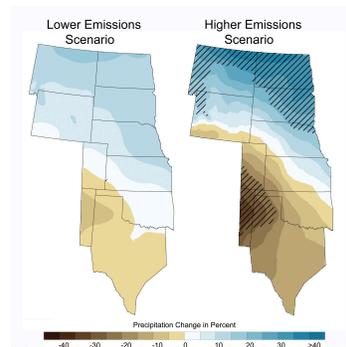


Figure 1: Rainfall changes in the Great Plains. (EPA 2013) [22]

Wheat are grown.

As you can see with a little inspection of the maps, the corn belt will likely see increases in rainfall by around 5-30%, depending on the scenario, while the wheat belt will experience decreases of 5-35%. Just this year, the Wall Street Journal reported a price spike of 3.5%, the biggest in three years, blaming the regional droughts across the nation for the jump [14]. If the scenario outlined by the EPA plays out and events like this year's drought continue and intensify, the price of those harvests will very likely rise due to increased costs of irrigation and/or a shrinking

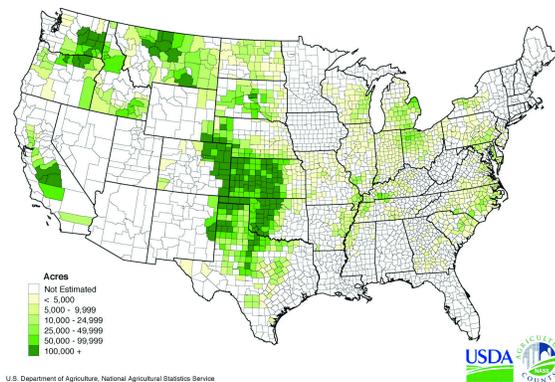


Figure 2: U.S. Wheat Belt. (USDA, 2010) [23]

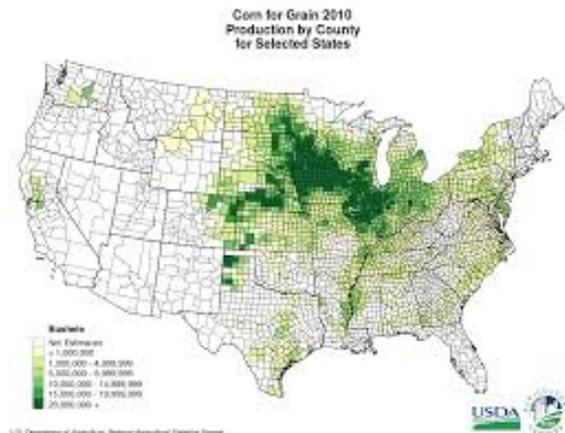


Figure 3: U.S. Corn Belt. (USDA, 2010) [24]

supply as crops fail. This will force Israel to either pay higher prices, or find alternative sources.

Russia and Ukraine are not exactly secure sources of grain either. NOAA estimates predict the average precipitation across nearly all of Ukraine will drop by 1-3 inches by the end of the 21st century. The southern regions, where the majority of the agriculture is grown in the country, is predicted to have the most severe drop in rainfall. Russia grows most of its wheat along its border with Kazhakstan and Ukraine, with the heaviest production being right along the borders [15]. In the growing regions around Ukraine and between the Black and Caspian Seas, there will likely be a decrease of around 1-4 inches, while the regions more to the north and spreading east are expected to get an increase— 1-3 inches as projected by NOAA [16]. Fittingly, the World Bank predicts that the southeastern region bordering Ukraine will experience a 10-20% drop in agricultural yields while the north and western growing areas could experience an increase of 5%. There are massive tracts of land even further north that are expected to also become more agriculturally productive. So Russia could shift agricultural production northward to make up for losses in the south, should it so choose. Ukraine, on the other hand, doesn't have this option.

POPULATION

Israel has a population growth rate of 1.8%, more similar to developing nations than developed, and is expected to reach 10-12 million inhabitants by 2035 as reported by their Central Bureau of Statistics. Having already started, the global grain prices will likely continue to rise as populations grow and arable land becomes more and more

scarce. The USDA's Annual Grain and Feed Report from 2011 warned of such conditions, suggesting that Israel would likely have to transition many of their fields from growing horticultural crops over to wheat production. If done so, it was estimated that national production could increase by 50,000 tons [4]. While this figure is rather large, it is rather insignificant in its ability to reduce the volume of imported grain that Israel currently relies on. With their imports standing at 4.506 million tons, 50,000 additional tons of wheat would only reduce the nations dependency on outside sources of wheat by 1.1%; just a drop in the bucket, really [4]. So although there is an opportunity for Israel to fill in a small gap in a grain shortage, it will be unable to cover the gap should the U.S., Ukraine, and Russia encounter serious crop failures and refuse to sell their goods at regular prices.

DESERTIFICATION OF US, RUSSIAN, AND UKRAINIAN SOILS

In addition to volatile rainfall patterns, the American and European breadbaskets are also threatened by desertification of their soils. The map below, produced by the U.S. Department of Agriculture, shows the global distribution of degraded soils in 1998. While it is slightly dated, it does provide good insight into the regions which have degraded potential for agricultural yields. The great plains has a vast area which has very high vulnerability to desertification, while the Black Sea Basin has moderate, high, and very high vulnerability. In both regions, vital organic matter and nutrients could be lost and crop health would suffer. As crops struggle or potentially fail, prices will rise as supply falls, posing another serious risk to the affordability of Israel's imported wheat. Not only is their imported wheat under threat, but as made clear by the map, the state of

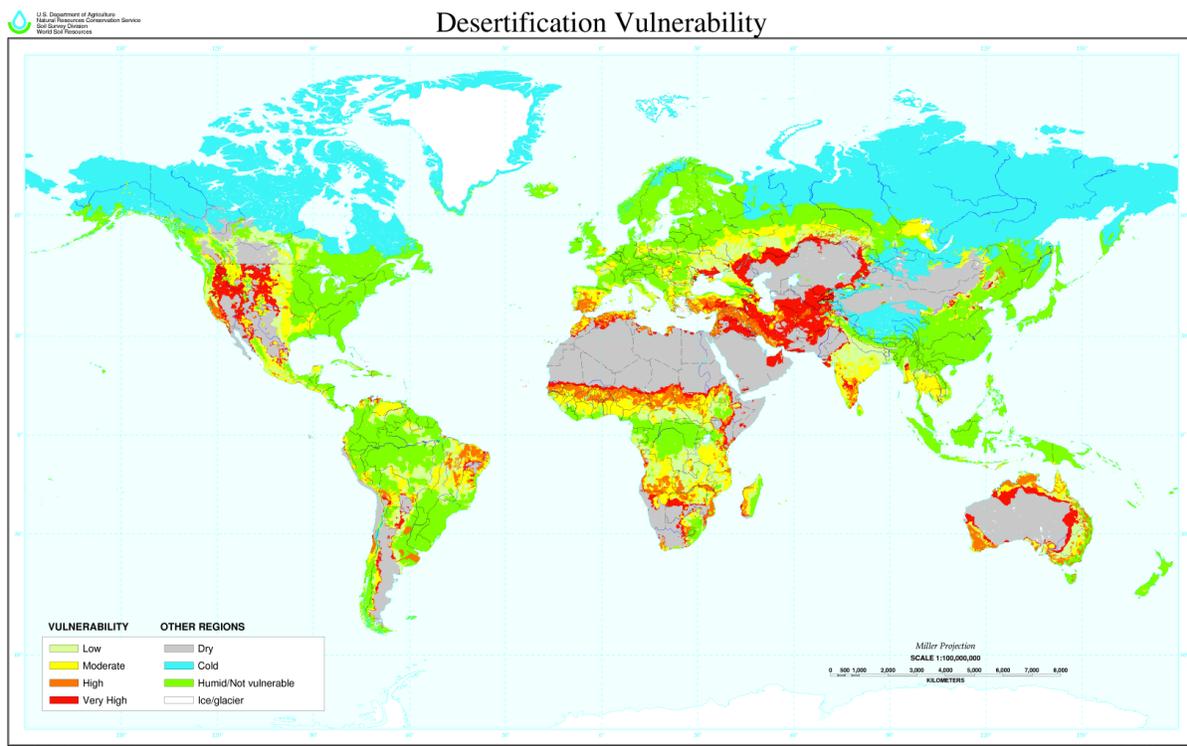


Figure 4: USDA, 2003 [25]

Israel also has high and very high vulnerability to desertification. This could lead to intense decreases in yields of the fruits and vegetables that they produce for local consumption and exportation. The result would be higher costs of food for the Israeli's and a smaller agricultural GDP.

POLITICAL DESTABILIZATION IN BLACK SEA BASIN

It is no secret that Russia and Ukraine have been on bad terms these last few months (February-May, 2014). Together, although not jointly, they control what is known as the Black Sea Basin, which is commonly referred to as the 'breadbasket of Europe'. The United States' Department of Agriculture estimated that together, 16.7% of global wheat exports originate from the two countries, some of which is destined for Israel. Upon the news of the Russian invasion into the Crimea peninsula, there was a spike on global commodity prices [17]. The U.K.'s Telegraph issued a warning of rising wheat and grain costs should the conflict successfully choke off trade routes on the 2nd of March, 2014 [18]. Should the conflict succeed in doing so, Israel will be forced to find an alternative source of grains.

FERTILIZER PRICE BUMP

Fertilizer, similar to gasoline and oil products, is synthesized from finite resource reserves. Nitrogen, Phosphorus, and Potassium, or NPK, are the three vital elements of fertilizer production. Nitrogen is plentiful in our atmosphere and can be synthesized easily. Potassium Oxide and Phosphorus Pentoxide are derived from potash and phosphate, respectively, and cannot be replaced, made, or substituted. Precariously enough, they are also two compounds that are absolutely vital for all processes that drive every kind of plant growth. Just like peak oil, current experts have been speaking up about the increasing rarity of both potash and phosphate and how their dwindling supply could both raise prices and, upon collapse, cause massive decline in crop yields. The chief investment strategist and co-founder of GMO, Jeremy Grantham, explains that 70% of the world's potash reserves are in Canada and 85% of all high-grade phosphate mines are in Morocco's contested lands of the Western Sahara [19, 20].

Index mundi has compiled data from the World Bank to show the price of fertilizer over time, shown in the graph to the right. Clearly, a price spike exists centered around the food price increase of 2008. This is concerning given that fertilizer use increases our societies' carrying capacity. More food means more people can live and eat, but once the very resource that facilitates this runs out, a crash in our carrying capacity is possible. This will be discussed in more depth later.

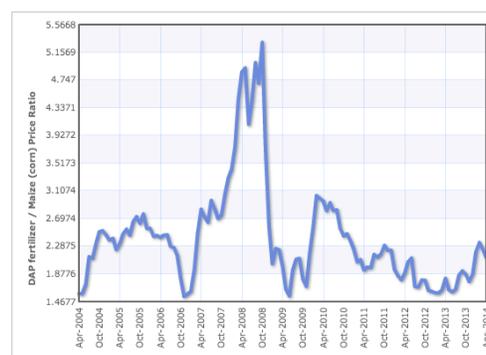


Figure 5: Global Monthly Fertilizer Prices. (Index-Mundi; World Bank) [26]

Average Price of U.S. Wheat

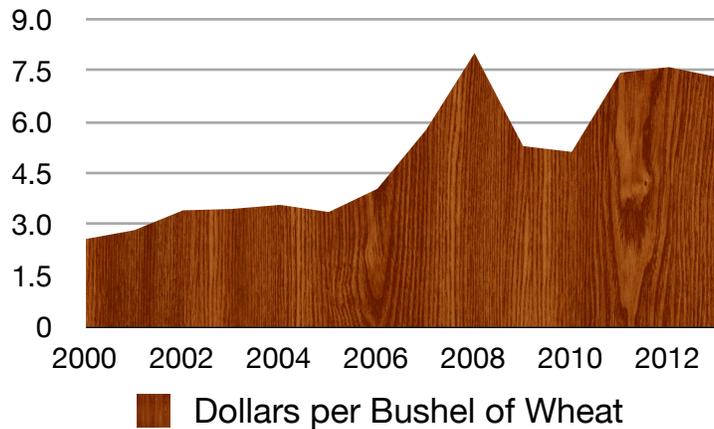


Figure 7 (University of Illinois' College of Agriculture) [28]

As noted before, Israel shifts their markets to the cheapest grain harvests, altering the quantities of grain bought from the U.S., Ukraine, and Russia depending on pricing. This speaks to their desire for cheap imported grain. Should the depletion of potassium and phosphate fertilizers become a reality as many experts believe, Israel will likely experience price increases in their imported grain, as well as the domestically produced animal products which rely on feed grain imports or fertilizers themselves. In figure 7, you can see a graph of the monthly average of U.S. wheat prices from 2000-2013, as sourced from the University of Illinois' College of Agricultural, Consumer and Environmental Sciences [28].

Comparing to the price of fertilizer above, it becomes clear how the price of fertilizer rises with the price of food. Even more, both fertilizer and wheat prices have yet to drop back to the levels in the early 2000's since the 2008 spike. Should another price surge in fertilizers bring with it higher food costs from the globe's breadbaskets, Israel could very easily see another doubling of food prices. Domestically produced foods could also see price bumps, as the average amount of fertilizer used per hectare of arable land stood at 200 kilograms in 2010 [29]. With such a clear dependency, a less affordable supply of fertilizer could result in the inability to buy for the less affluent demographics.

CLIMATE CHANGE

Climatic swings have already shown just how volatile the price of vegetables are in Israel markets when production droops. A winter storm in December of 2013 sent price shocks through the local produce markets, causing the cost of commonly eaten fruits and veggies like tomatoes, lettuce and cucumbers to rise by 200-400% [30]. In an effort to preserve a relatively low cost of living, the Israeli Agriculture Ministry dropped the tariffs on imported produce to help "reduce the price of a family's food basket," says Finance Minister Yair Lapid. This severe inflation of prices is indicative of the susceptibility that Israeli food markets have to the type of disturbances climate change is expected to bring. In Israel's National Report on Climate Change, as prepared by the U.N.'s Framework Convention on Climate Change, it is reported that increased temperature variability, volatile rain patterns, and increased heat and desertification can be expected in the next century [31]. Rains are expected to come in shorter durations and with higher intensities, causing erosive flash floods and further desertification. Israel's crops which aren't heat or cold sensitive will likely struggle with the seasonal shifts while nearly all crops will need supplemental fertilizer should desertification occur.

Ethiopia

Ethiopia has a highly diverse geography that equates to a range of agricultural productivity levels due to differences in altitude and precipitation. Despite an increase in studies performed within the country, accurate data is especially difficult to ascertain as the majority of farms in Ethiopia are smallholder farms of modest size (a hectare or less), and are a means to self-sustenance for the owners [32].

Ethiopian Diet and Consumption

A 2011 study from the International Food Policy Research Institute titled 'Foodgrain Consumption and Calorie Intake Patterns in Ethiopia' calculated what percentage of Ethiopians' budget went towards buying various food products. They found that on average, 46% of a family's budget went towards the purchase of cereal products, nationally [33]. In rural areas they made up around 54% of the diet, followed behind by Ensets at 17.5% and then vegetables at 14.5% [34]. While these values are sensitive to both price swings and income distributions, cereals make up the majority of the Ethiopian diet in all regions. That being said, a 2009 study from the Ethiopian Journal of Health Development found that Ethiopian urbanites had significantly lower levels of vegetable cultivation and consumption [35].

Ethiopia's Grain and Feed Annual Report, prepared by the USDA for the Global Agricultural Information Network reported that the exportation of grains was banned in the country. The International Food Policy Research Institute facilitates a Food Security Portal, which provides "comprehensive and detailed information country-by-country on food policy," as the site promotes [36]. On their Ethiopian profile, they cite the country as having produced around 7 million metric tons of wheat, maize, rice, and soybeans in 2010. Wheat and maize make up the majority, with 3 and 3.9 million tons of production apiece, respectively. Rice production trails with just 71,000, and just under 8,000 tons of soybeans were produced [37]. With the nation's history of food insecurity, all grains are essentially restricted within the borders to feed the Ethiopian population, though. Some small exports of soybeans do exist but all other commodities' exports are negligent.

Imports are also highly regulated and essentially controlled by the government through restricted use of foreign currency [32]. Unlike the nation's exports, the imported wheat, maize, rice and soybeans are noteworthy, but uncertain. The values waver inconsistently from year to year, although rice has grown significantly, tripling in volume between 2009 and 2011 (from 22,287 tonnes to 71,405). Wheat and cereal imports were also high last year (at 1,654,280 tonnes and 1,850,840 respectively), although they had decreased slightly from their peaks in 2009. Nonetheless, they too had doubled in volume between 2007 and 2009, while corn imports spiked and fell dramatically during the same general period.

Sources of Food

Overall, Ethiopia is one of Africa's largest grain producers, and also boasts one of the largest livestock herds in Africa despite its feed grain industry still being in its infant stage ^[32]. Nonetheless, the country has experienced food insecurity for decades ^[38]. Wheat, teff, maize, barley, and sorghum make up the five major cereal grains of Ethiopia's food economy. Local production feeds the small-time farmers who harvest it and also portions of the urban populations through local markets. Another major crop is the Enset, a large yielding, carbohydrate intensive crop that belongs to the banana family which is grown mostly for local consumption and trade amongst small farms. Measures of total production are dated and flawed, but range from 2.4 million to 5 million metric tons a year ^[40]. Vegetables like potatoes, garlic, shallots, and chillies are grown on rain-fed plots, while vegetables requiring more water like tomatoes, spinach, and carrots are mainly saved for the irrigated land. This being said, very little amount of farmland in Ethiopia is irrigated. Nonetheless, vegetable yields have been steadily rising since 1993 and rested at just over 1.2 million metric tons in 2009 ^[41].

Price of major commodities:

Certainly, Ethiopia has vastly improved their food security programs since the days of famine in the 70's—a point that will be expanded on later in the 'Resiliency' section of this essay. Nevertheless, an estimated 40% of the population is still undernourished ^[37] and famines have unfortunately and sporadically occurred since the devastating times of the 70's and 80's. Despite the government's great undertaking in increasing food security, price volatility for staple foods still exists. With the onset of the 2008 global recession, domestic prices on grains began to climb, doubling within months as institutions and programs struggled to flood the market with lower-priced imports ^[42]. During the same period, global wheat prices were also soaring, increasing by around 75% in a single year starting in April 2007 ^[43]. It is important to note, though, that the global market price spike came before the Ethiopian price spike, so there is a short lag in the pricing whiplash. Also important is that although delayed, the Ethiopian price spike was slightly more extreme than the global one, indicating that Ethiopian markets might be more fragile than global ones.

Threats to Food Security

DROUGHT

The future of Ethiopia's rain supply is not as dire as many other African nations. While the northern third of the country is expected to see a drop of 1-4 inches, with the 4 inch drop only occurring in a small pocket in the north corner, the south is actually expected to receive more rain by the end of the 21st century ^[16]. Up to 6 inches of additional rain could come in a pocket in the southwest, while the majority of the southern end of the country should see an increase of 1-5 inches of rain, excluding the

arid region approaching the horn of Africa. Nonetheless, a few extra inches *on average* doesn't mean that the country will become immune to droughts. As the BBC and Time Magazine reports, Ethiopia has been experiencing a cycle of droughts and famines for decades [44, 45]. While the expected increase in rains certainly won't hurt, Ethiopia is expected to experience acute droughts and increased rainfall variability in the future which could undermine their agricultural productivity [96].

Just like in the past, this has the potential to cause famine and even political destabilization through rising food prices. The 1984-1985 famine within Ethiopia caused 1 million deaths, and while a civil war exacerbated the situation, drought was seen as the main driver. From 1981 to 1985, average grain prices rose by a factor of 3, 4, and 5 for the three staple grains [45]. Since then, food aid has been at least slightly successful in avoiding similar scenarios, but the aid coming in is shrinking in volume. In 2012, Ethiopia's Grain and Feed Annual Report, prepared by the USDA for the Global Agricultural Information Network, reported that domestic wheat prices in Ethiopia have risen due to dwindling food aid in the last few years, specifically in wheat imports. This has reduced the countries emergency reserves, reducing the supply and driving prices up [32].

DESERTIFICATION

85% of Ethiopia's land mass is considered to be at least moderately degraded [46]. The amount of severely degraded soils sits at around 2 million hectares, and nearly all of the nation is vulnerable to wind and water erosion, as well as salinization and alkalisation. The economic effects of desertification were estimated by four entities and cited in the U.N. Convention to Combat Desertification's 2013 report titled *Economic and Social Impacts of Desertification, Land Degradation and Drought*. As a percent of total Agricultural GDP (AGDP), desertification was estimated to cause a loss ranging from 2-6% of the total AGDP of Ethiopia [47]. These numbers are contested, though. In a 2001 report in the *Economic Policy and Sustainable Land Use contribution to Economics*, Michiel Keyzer and Ben Sonneveld found that there wasn't a strong correlation between land degradation and fertility and crop yields. This was believed to be because of a couple reasons. One being that soil degradation usually occurs on the already poorest of soils. Also, degradation is usually compensated for through the application of fertilizer [48]. The range of conclusions in the field show how difficult it can be to secure reliable estimates of how desertification detracts from agricultural productivity. One thing is for certain though: if productive soils erode, agriculture will suffer without additional inputs. After all, crops must attain their nutrients from somewhere.

FERTILIZER PRICE BUMP

Fertilizer is often heralded as a solution to desertification. It can replace lost nutrients, and also boost production for a number of varieties of crops [49]. Currently, its use in Ethiopia is low, but it has been rising steadily since 2003 when consumption stood at 5.7 kg per hectare. In 2010, that number reached 22.8 kg per hectare of arable land [29]. Given that 14.56% of Ethiopia's 1.127 million square kilometers is arable land,

the total number of hectares of agricultural land falls at 16,409,120 ^[50]. At 22.8 kg per hectare, Ethiopia could very well have used around 3.74×10^3 metric tons of fertilizer in 2010.

But this number will likely increase. There is currently a large effort being made by the Ethiopian government to remove large pastoral populations and small time farmers from large tracts of fertile land in order to open various regions up for investment ^[51]. Foreign bodies have been buying or setting up leasing contracts with the government for these lands, mostly for the purpose of installing large-scale agriculture networks for producing cash crops such as sugar-cane ^[52]. India is one of the major purchasers of land in Ethiopia, although China has also been a major investor in the nation and continent as a whole ^[53]. These investments have brought little returns to Africans, it may be worth noting.

Already, agribusiness is gearing up to take over new, major markets in Ethiopia. Several fertilizer manufacturers have already performed full market analyses, estimating just how much fertilizer could be used to boost Ethiopian production ^[54]. In the Ethiopia Fertilizer Assessment, as commissioned and funded by the United States Agency for International Development (USAID) under the Feed the Future initiative, estimates were made on the amount of Nitrogen (N), Phosphorus Pentoxide (P₂O₅), and Potassium Oxide (K₂O) that the top 5 grain crops would remove from the soil. They were able to discern an approximate amount of fertilizer needed to maintain yields and the soils health. In total, it was estimated that Teff, Maize, Sorghum, Wheat, and Barley removed 253.1×10^3 metric tons of the three nutrients from Ethiopian farmland every crop cycle ^[55]. The authors used a specific multiplier to find the amount of fertilizer needed to replace the leached nutrients. Using the average of the two ratios used, it was estimated that 504.2×10^3 metric tons of fertilizer would be needed to replenish the soils ^[49]. An upward trend in fertilizer use and dependency becomes clear, and just like Israel, Ethiopia's vulnerability to a spike in fertilizer prices can be seen as a serious threat to food security.

INADEQUATE DISTRIBUTION NETWORK

Ethiopia's transportation and distribution network is still heavily reliant on the roadways that spread across the nation ^[56]. The Encyclopedia of the Nations estimates that around 75% of the farms in Ethiopia have more than a days walk to the nearest road, forcing the majority of the produce from farms to be carried by pack animals. While the major urban centers are efficiently connected, great challenges still clearly exist for rural communities' access to roadways ^[57]. Some waterway transport is used on the Baro river, but all oceanic shipments must come in through Djibouti's port ^[57].

The road network certainly has its flaws, but the rail network is essentially non-existent. There is a single line from the nation's capital, Addis Ababa, to neighboring Djibouti ^[57]. China has, however, pledged a \$1.5 billion dollar investment in order to build a railway from Ethiopia's northeastern potash mines into Addis Ababa ^[58]. Even more, the Ethiopian Railways Corporation (ERC) has also started construction on a 5,000km system of railways which will connect most all of Ethiopia. Abebe Miheretu, who serves as the head of public relations for the ERC, explains that the railway will help "connect Ethiopia economically and increase access for imports and exports" ^[59].

With these new projects on the horizon, Ethiopia's ability to distribute goods and vitalize their economy will increase with time; a phenomena the rural populations will undoubtedly welcome after being plagued by relatively poor transportation systems for decades.

CLIMATE CHANGE

A study performed on 3,000 household crop yields across four major regions of Ethiopia for the 2011/12 harvest year found that yields varied from farm to farm. While 78% of farmers reported that they experienced similar yields to previous harvests, others noted a much lower yield (18%), and an even smaller proportion saw a rise in yields (4%). These decreases and increases were fairly concentrated, though, seen almost entirely in just 2 crops for increased yields and 3 crops for the decreased yields. The researchers weighed in on the experience of the farmers as to the sources of these variations. Gains were attributed to plentiful precipitation by 64% of the respondents, while 23% of them attributed their gains to fertilizer use. Declines were of similar nature, with 62% of farmers blaming poor rainfall. The runner up was instead pests and disease, where 16% of farmers found their crops had been attacked. And although this was mainly rampant in vegetable and oilseed growers, it also was reported to have affected between 9-20% of cereal crops ^[60].

The study makes clear how effectively climatic fluctuations, specifically in rainfall, can reduce agricultural yields in Ethiopia. With climate change poised to intensify precipitation volatility and uncertainty, Ethiopia's farmers will likely bear the brunt of a climatic slap to the face ^[62]. A stable water supply will simply be less and less available as extreme events that once had low probabilities of occurring increase in frequency. But although rainfall variability and changes in the average rainfall are unnerving, floods are particularly threatening to crops in terms of outright damage ^[63]. They have the ability to wipe away fields if powerful enough. These climatic threats will ultimately undermine economic growth along with food security, and, should a severe food shortage occur, much progress in reducing poverty and achieving economic stability could be lost ^[63].

Resiliency

There exist a number of threats to both Israel and Ethiopia's food schemes and food security that, based on experts' estimates, will likely affect them both within this century. But before applying each one, it is necessary to speak to both of the nations' food systems' efficacy for resilience. Resiliency describes the amount of change a system can undergo before a change in the system itself takes place. Resiliency can also refer to the ability to self-organize. In this sense, an adaptable scheme is also a resilient one. Adaptability can be facilitated or restricted, as can the ability to withstand shocks and changes.

Nearly all systems have an aspect of resiliency, as well as thresholds. When a system absorbs enough change, it eventually is forced to alter its structure. It will pass

a point of pressure that forces it to do so. This pressure point is what is known as a threshold. In terms of food security and food schemes, it is difficult to confidently define a threshold that when crossed, forces a society to falter under the pressures of food insecurity. Even more mysterious is how exactly a society will respond or alter in structure or character once these thresholds are passed. One thing is for certain though, food scarcity does have the power to reshape societies. Food security policy, international food aid and relief, and massive food reserves help increase resiliency to food shortages and price spikes. But at the same time, global climatic shifts, resource scarcities, and political destabilization can all compound to produce a daunting threat to food systems. In the following sections, the buffers that each nation have against the aforementioned threats are explored.

Israel

Israel has 750 million cubic meters of water being naturally produced within their borders, recharging the groundwater sources that they use for their urban population as well as their agricultural sector ^[8]. While this is certainly not equivalent to their consumption, it does serve as a safeguard in the case of water scarcity. Should a water shortage emerge, the nation will assuredly have at least 750 million cubic meters of water to tap into each year. A more promising phenomena is that their agricultural sector's water efficiency has been improving immensely in the last couple decades ^[64]. In 1988, the equivalent of \$33 was produced per cubic meter of fresh water withdrawn. In 2011, that figure stood at \$90.5. Israel is hailed as another (perhaps superior) silicon valley ^[65], with a booming startup economy centered around technological innovation. Water conservation technology is one of their major focuses. As the Washington Post even reports, 'Israel knows water technology', and it will likely continue to be a leader in the field for years to come. After all, Israeli exports of water products have tripled in five years, reaching a value of \$2 billion in 2013 ^[66]. Undoubtedly, the Israeli administration would be open to sending their best products to the breadbaskets of the U.S. and the Black Sea in order to ensure their wheat supply through the drier future.

In addition to water conservation technology, Israel could apply their innovative might to developing fertilizer conserving technology as well. Currently and to our knowledge, no substitute for phosphorus exists, but perhaps Israel could invent new ways to synthesize it into usable fertilizers. The same goes for Potassium based fertilizers. Sources from which they are made are finite—and running out—but perhaps different source material could be utilized if innovations were made in fertilizer synthesis. If not, Israel already utilizes proper fertilizer monitoring systems that conserves fertilizer, reducing the total amount needed per acre ^[67]. Conservation and efficiency will likely need to become paramount in Israel, given that their population is expected to grow from just over 8 million to around 11.4 million by 2035. Somehow, they'll have to do more with less.

In terms of combating political destabilization in the Black Sea Basin, Israel has their hands tied. Supporting one side of the conflict in order to bring it to an end would also sever friendly ties to the other. Should they interfere, they may lose one of their major grain suppliers. Desertification of the two breadbaskets is another lost cause. A full blown assault by Israel on U.S., Ukrainian, and Russian agricultural practices which

stimulate desertification is unlikely at best. Israel can, however, distribute the agrochemical products they produce to their supplying nations in an effort to revitalize the soil. This, of course, is dependent on a reliable supply of the agrochemical source material.

Israel lacks well publicized policy directly addressing food security in the case of an acute food shortage. Should this ever occur, it does have an advanced transportation network that could sufficiently distribute food aid to hungry regions, though. While lacking emergency relief policy, Israel does recognize that wealth disparities within their population create a lack of access to food for the poorest demographics. Joseph Shapira, State Comptroller of Israel, released a statement which explained that 900,000 Israelis had gone a whole day without food or had otherwise cut their intake due to poverty in 2011 ^[68]. In response to this startling statistic, Israel created a National Nutritional Security Council which advises the welfare minister in decision-making and policy planning. Each year the council helps distribute the \$200 million set aside for food aid, where eligible families can apply and receive monthly allowances after their assets and expenditures are examined. Food baskets and food voucher options are also being explored as options for food disbursement ^[68].

Ethiopia

As stated before, parts of Ethiopia will likely see a slight increase in yearly rainfall, but this amount won't make the nation immune to drought. Especially when the regions which are expected to receive less rain are considered. 12.7 million small-scale farmers^[69] who depend on steady rains to grow the food that they eat and make a living from will likely experience years of low rainfall in the future ^[70]. What's disconcerting is that famines usually follow droughts in Ethiopia, speaking to the nation's overall vulnerability and dependency on reliable rains. Some of this vulnerability could be circumvented with water-conserving irrigation systems, but nearly all of the farmland is rain-fed ^[71]. In this case, Ethiopia lacks resilience against droughts and water insecurity.

It also lacks resiliency against soil nutrient deficiency. Desertification plagues the country's farmland, affecting 71.5% of the total land area ^[72]. Estimates from the FAO predict that Ethiopia will be unable to feed 44 million of its inhabitants by 2025 even with moderate inputs such as fertilizer ^[73]. Those estimates are also assuming that all arable land is used to grow food crops. While an industrialized food production system with high inputs can avoid some of the downfalls of desertification, Ethiopia's millions of small-scale farmers would likely find it hard locating the capital necessary to set up such a system. For these reasons, Ethiopia lacks resiliency to desertification. The government is well aware of their vulnerabilities to food shortages, though. A history of deadly famines have spurred them to take steps in ensuring a system for crisis management.

Ethiopia's Ministry of Agriculture works with a number of institutions within the country to produce a heightened level of food security through enhancements to food production, food aid, and price stabilization. To accomplish this, six major instruments are utilized:

1. Farm Modernization: Through pilot credit schemes, programs to increase productivity, fertilizer production and use optimization projects, biotech studies, the promotion of soil conservation techniques, and the organization of farmers into more productive groups, the Agricultural Transformation Agency of Ethiopia is helping to modernize the nation's agricultural sector. It is a daunting task given the resources, but one that is mandated by the government nonetheless ^[38].
2. The Emergency Food Security Reserve (EFSR): This reserve of mostly wheat, maize and sorghum was built in 1972 following a severe famine as a means to replenish the supply of grains during food droughts. It currently has a capacity of 410,000 metric tons, although the capacity is expected to reach 3 million by the end of 2016. Storage sites are located in regions prone to famine. It operates by releasing the necessary quantity of food to the region in need, and orders a shipment of equal volume right away as a means of replenishment. The food released is done so with a promissory note ensuring this replenishment from an eligible donor agency like USAID, the EU, the WFP etc. In this way, the EFSR can maintain a steady balance of food ^[38].
3. The Productive Safety Net Program (PSNP): This program is used as an early alert system against potential food calamities. Funded by both the government and donors, the PSNP helps target the poorest of the population and provide either cash or food to those who qualify. They also claims to help increase agricultural productivity and the program is seen as the backbone of safety net programs within the nation (IBRD 2011, p.33). (IBRD, Project Performance Assessment Report: Ethiopia Productive Safety Net Project. Report No.:62549, June 16, 2011)
4. Price Stabilization: As local stores of grains dwindle, prices will rise. A measure employed to reduce this is the EGTE (Ethiopian Grain Trade Enterprise), which operates with world markets to pump a commodity into the market at a deflated price. If action is needed on a shorter timeframe, the EGTE might borrow from Ethiopia's own EFSR and use it as an injection instead. These mechanisms, while necessary for price stabilization, can also come at a great loss to the Ethiopian government and national bank ^[38].
5. The Ethiopian Commodity Exchange (ECX): Although dealing more specifically with price insurance, the ECX operates as a market for farmers to bring their crops in to trade within a more transparent system. The exchange has been very successful, with 17 warehouses trading approximately 60% of Ethiopian coffee, for example, at prices significantly higher than those before its establishment ^[38].
6. Financial Insurance and Mechanisms: Micro-credit programs have began to take hold in pockets of Ethiopia, although the aid is spread thin. While providing vital investments into small farms, the system is also flawed in that it does little to market the extra crop yields or insure their sale at a certain price. Government involvement has been generally devoid in micro-credit though, despite the substantial need. The government does supply production credits to commercial farms, though. In addition, a crop insurance system has been put in place. Sponsored by a number of international firms originating from the U.S. and Switzerland, the program is available for a premium, or through 'work for insurance' arrangements. The insured

are compensated for losses as calculated through a weather-based index. This is a novel system though and has yet to be proven to be fully successful ^[38].

Threats: Applied

There is a great deal of uncertainty in how the future of global food security will play out. Trade partnerships, alliances, food policies, regional climate differences, and many other elements will play large roles in how food production, distribution, and trade will take form in the future. In the following section, the threats discussed for each country will be applied to the production and consumption levels of Ethiopia and Israel to get a notion of the magnitude of the threats.

Israel

Israel is reliant on the global market to supply its grain. The world grain prices, on the other hand, are subject to multiple phenomena, like regional droughts similar to the one occurring in the Midwestern U.S. right now. Experts are already releasing warnings of another food crisis akin to the 2008 price spike caused by, among other things, reduced rice and wheat harvests induced by a 2005-2006 drought ^[74, 75]. In January of 2007, wheat prices stood at \$196 per metric ton. By March of 2008 the price had risen by 123%, reaching 439 dollars per metric ton ^[43]. Corn prices also rose between January of 2007 and June of 2008, from \$165/metric ton to \$287/metric ton; a 74% increase ^[76]. This spike was seen as a result of droughts in wheat-producing regions, diminished reserves, rising oil prices, increased meat consumption, and the emergence of agro-fuels ^[75]. The coming crisis will likely be caused by corn shortages rather than wheat and rice shortages, but an increase in corn prices will likely also mean an increase in wheat prices, says food security expert Robert Thompson from the Chicago Council of Global Affairs ^[74].

Just like the 2008 crisis, many other factors will come into play. Should grain producing nations begin to stockpile reserves in an effort of self preservation, the prices will rise even more. If oil prices continue to rise, the high input production systems of the U.S., Ukraine, and Russia could easily begin demanding higher prices. All the while, developing superpowers like China, India, and Brazil boast massive populations of growing middle classes that will demand higher volumes of meat and dairy products into the future, furthering the expansion of global grain demand and fueling high prices ^[77]. If the price of grains were to climb with a magnitude similar to that of the 2008 spike, Israel would be forced to double their budget for grain imports, more or less. This burden could be partially shouldered by the government through subsidies, but generally price swings tend to be absorbed by consumers, usually affecting the nation's poorest residents ^[79]. Using loose estimates based on values from the 2008 crisis, which essentially saw a doubling in food prices, Israel could see corn prices rise to \$416/metric ton from the current \$208, and wheat could rise to \$612/metric ton from \$306.

These potential jumps of the future will also likely be facilitated by rising fertilizer prices, as seen during the 2008 food crisis. That being said, it is hard to estimate exactly how or when a shortage in fertilizer products will bring detrimental effects to the global food economy as discussed in earlier sections. A study from MIT promotes that without fertilizer, farmers could expect to harvest only 50-71% of their original yields, as found in field studies from Kenya ^[78]. As soils around the world lose topsoil and become less productive, there will likely be increased use of fertilizer to make up for nutrient loss, though. When this may occur is reliant on the agricultural practices and efforts in soil stewardship from the producing nations. When the threshold will be passed, turning viable soil into unproductive dust is a mystery, just as much as when an extreme-weather anomaly will render a harvest obsolete—or when or if political destabilization in the Black Sea Basin may cut off supplies of grain.

The three phenomena's obscurity should not write off their legitimacy, though. Political destabilization, climate change, and fertilizer scarcities are real threats to food supplies that have already become a reality and will likely remain as issues through this century. As can be seen by the intense rise in vegetable prices following an Israeli winter storm, it is clear that local production of a staple Israeli food is certainly vulnerable to climatic swings. Just from a single storm, local prices on fruits and vegetables are able to inflate by 200-400% ^[30]. What is especially troubling is the idea that any combination of these threats could occur simultaneously, resulting in a cumulative price increase, as well as a cumulated increase in food scarcity and hunger.

Ethiopia

Food production and security issues that have persisted in Ethiopia for decades will likely continue for the next century, becoming more variable, but intense ^[63]. Specifically, inconsistent rains will continue to plague the agricultural lands, likely evolving into shorter, more intense storms that may provide large quantities of water, but also low retention and high erosion. These intense rains have the power to cause severe floods that may destroy entire agricultural plots, while the dry periods between such events will degrade production yields. In both the wet and dry seasons, then, Ethiopia's croplands are under threat from both too dry and too wet of conditions.

The U.N.'s Convention to Combat Desertification estimates that in the next 25 years, the global food production system could suffer up to a 12% loss in productivity due to land degradation. By their calculations, this could drive world food prices up by 30% ^[80]. The area of land in Ethiopia that is threatened by desertification could easily see a decline in production. What would be even more problematic is finding aid for the 38.7% of the nation's population that still lives below the poverty line ^[81]. This group will likely struggle to access foods they can afford in the midst of rising global food prices, especially if or when major stocks are bought by those countries which can better afford them, like Israel, for instance. In extreme cases, even the aid or grain imports that do make it within the borders might have difficulty reaching those in need of it most. With around 75% of Ethiopia's farmers more than a day's walk from the nearest road, it would be extremely difficult to reach the rural populations of Ethiopia ^[57].

Increase in global grain prices do more than affect the major importers of grain and cereals, though. As the prices rise worldwide, food aid levels drop from the

developed world. As the largest food aid donor of the world, the U.S. cut their efforts by more than half between 2000 and 2007 ^[82], the same period that saw an increase of global grain prices by 85% ^[43]. Should a food crisis drive prices up once again in the midst of a dry year for Ethiopia, the government might find that finding shipments of grains to replenish their EFSR will cost them dearly in the midst of their desperation.

Discussion

It is difficult to accurately quantify each of the threats in terms of food supply reduction or hunger rate growth for Israel and Ethiopia, but a trend does emerge that is useful. The threats covered in each of the country's profiles expose vulnerabilities that each nation's food security is subject to. While no threat is guaranteed to bring a specific loss by a specific time, the cumulated array of hazards suggest a future that will see many more food crises occur and an increase in food price volatility. This is not a novel phenomena, though. From 1960-1985, world food prices experienced booms and busts, increasing and decreasing by a factor of 80-120%—most commodities doubled (rice quadrupled) in price during the food crisis of the early 1970's ^[83]. As noted by the International Food Policy Research Institute (IFPRI) in their report titled "Reflections on the Global Food Crisis," these price spikes were accompanied by sharp rises in fertilizer and energy costs as well. Although not discussed intensively within this essay, rising fuel and energy costs do have major influence on rising food costs ^[84]. This essay was intentionally geared towards threats stemming from environmental issues, however the dwindling global oil reserves do represent a scarcity that will continue to influence global food prices.

The Joint Institute for the Study of the Atmosphere and Ocean (JISAO) has data outlining drought levels in the Sahel region of Africa which show that during the same period of high food price volatility in the early 1970's, low rain levels were plaguing Africa ^[85]. Rainfall levels in the U.S. were not lacking during the early 70's, just before the crisis ^[86]; however, Ukraine was experiencing a multi-year dry spell from 1971-1974 ^[87]. It almost goes without saying that rainfall differences between the grain producing regions of the world is expected through the future. While these differences may sway the production that reaches international markets, regional droughts will have the power to disrupt local production in regions like Ethiopia and the Sahel as a whole.

Decreased rainfall and an increase in fertilizer and fuel costs are seen as compounding drivers of the 2008 and 1970 food crises. These crises doubled, tripled, and quadrupled major grain prices. Should these same phenomena become a reality once more, a similar jump could very well occur. But these aren't the only threats. Increasing populations of global superpowers drives intense importation of staple goods, fertilizers, and energy despite rising food costs ^[83]. This drives prices up even higher as the global supply of commodities is quickly eaten up. Global agricultural productivity has grown at a rate of around 2.3% for the last four decades, doubling every 30 years or so ^[88]. This figure stands comfortably above the global population's rate of growth of 1.14% ^[89]. That being said, a 2013 report from the *Nature Communications* journal indicates that yields might be experiencing a plateau, and suggests that food security projections are often overly optimistic in terms of yield gains

^[90]. This could prove troublesome as global population approaches 9 billion and arable lands become rarer and rarer.

Political and social conflicts like the one between Ukraine and Russia may become more prevalent as countries vie for the remaining tracts of productive land across the globe. Already, massive land grabs are occurring in Africa and the rest of the developing world that speak to the awareness of resource scarcities in the face of rocketing demand for food ^[91]. This continued strain on the world's farms and fields could mean even more intense price spikes in the future, as well as overall increases in food prices that stick, instead of peak as we saw with the 1970 crisis. We are getting a taste of this now, where food prices have yet to return to their levels before the beginning of the price hike in 2008 ^[92].

In summary, should a number of threats become reality, the following increases in prices could result, based on the historical trends and literature focused on food crises as discussed above. The threat of drought on producing regions has the power to raise global prices on staple food commodities by a factor of 2-4 and, in Ethiopia's case, necessitate increased imports or food aid. Israel would be hit the hardest by swollen global prices, while Ethiopia would have some support from local production. Climatic swings and anomalies, including floods and winter storms, have the power to wipe out entire crops, increasing local prices by another factor of 2-4. Desertification could reduce supply of farmland and therefore food to an extent that brings a 30% rise in prices. Political destabilization of the Black Sea Basin could cut off supply chains, forcing trade partners like Israel into sourcing their staple grains from other sources who would undoubtedly be aware of the stifled competitor and increase prices in light of increased scarcity.

Should fertilizers become increasingly rare as expected, their prices will likely rise sharply as seen during the 2008 food crisis. This will cause food prices to rise directly, or perhaps force farmers to halt their uses, which in turn would decrease production down to 50-71% of its original volume, thereby also increasing prices through reduced supply. The U.S., Ukraine, and Russia's input intensive grain producing economies will be severely affected should this happen, potentially creating a global price spike or grain shortage unlike anything seen before. While this alone could easily increase prices by a factor of 2, investors in the futures markets of global food trade could exacerbate this further. Food economy-savvy investors will likely have the resources and aptitude to monitor fertilizer prices and the fertilizer industry as a whole. Should they see a shortage coming (from any of these threats, really), they could drive prices up through intensive investing in futures markets. This phenomena was seen as one of the main drivers of the 2008 food crisis ^[93].

Two Scenarios

The prices of food depend on a large array of factors that essentially affect two activities: production and distribution. Droughts, climate anomalies, fuel costs, nutrient deficiency and desertification affect production levels. Political stability (or lack thereof), inadequate distribution networks, and future markets affect distribution and access. These all have multiplying effects, but not of the same magnitude. Shortcoming of

production are the ultimate drivers of supply, and carry heavy influence on pricing, or in Ethiopia's case, the level of hunger. In the table below, I have summarized the potential effects of each of the threats outlined in this essay and made estimates in quantifying these effects in two scenarios. The first is one in which the threats become realities with a smaller intensity, either through chance or with the help of government and/or institutional intervention. The second scenario outlines a harsher reality in which the threats to food security have a greater influence on pricing and production and little institutional intervention takes place. These scenarios represent future possibilities, not predictions.

Threats	Israel		Ethiopia	
	Mild Scenario with Governmental and Institutional Intervention	Extreme Scenario Lacking Institutional Relief	Mild Scenario with Governmental and Institutional Intervention	Extreme Scenario Lacking Institutional Relief
Drought	Cost of staple goods (Grains, Fruits, Vegetables) double due to drought in either Israel or in the grain producing nations. Israel's population suffers from higher food costs and increased poverty.	Cost of staple goods (Grains, Fruits, Vegetables) quadruple due to drought in either Israel or in the grain producing nations. Israel's population suffers immensely from higher food costs and much higher levels of poverty.	Local production of food suffers lower yields. The Ethiopian government delivers emergency reserves and imports food aid for nation's poorest demographics. Prices of staple good double. Mild famine occurs.	Local food production essentially collapses. Governmental food aid is insufficient in making up the difference. Massive fatalities occur, exacerbated by civil unrest and compounded by mass migrations.

Threats	Israel		Ethiopia	
	Mild Scenario with Governmental and Institutional Intervention	Extreme Scenario Lacking Institutional Relief	Mild Scenario with Governmental and Institutional Intervention	Extreme Scenario Lacking Institutional Relief
Population	Populations continue grow but are leveled off through education campaigns and human development. Pressures on limited resources increases price volatility moderately.	Populations continue grow at historical rates. Pressures on limited resources increases intensely, causing extreme price volatility as consumption continues to rise and stocks dwindle.	Although less of an issue for Ethiopia, population pressures could still spur resource competition. Human development and economic sophistication might decrease population growth. Only slight increases in food prices over time occur as demand grows.	Population growth rate remains on par with the rest of the developing world, spurring large increases in rural and urban populations. Food pressures increase, necessitating higher volumes of food aid. Domestic food prices rise.
Political Destabilization of the Black Sea Basin	The Israeli government foresees political destabilization, securing stronger trading partners as alternatives. The new food supply chain is set before the old one collapses, muffling the price shock to more reasonable levels.	The Israeli government does little to prepare before trade in Black Sea staple grains is stifled. The global grain market becomes aware of the immediate increase in demand and responds with higher prices. Israel's population suffers from and intense increase in staple grain prices.	N/A	N/A

Threats	Israel		Ethiopia	
	Mild Scenario with Governmental and Institutional Intervention	Extreme Scenario Lacking Institutional Relief	Mild Scenario with Governmental and Institutional Intervention	Extreme Scenario Lacking Institutional Relief
Desertification	Decreased farming intensity slows desertification, but doesn't halt it. Yields in fruits and vegetables decrease, bringing higher food prices, shrunken exports, and a lowered agricultural GDP. Desertification of grain producing nations could decrease yields and exports, increasing global grain and commodity prices by 30% ^[94] .	Israel and the grain producing nations' vulnerable soils continue to be farmed intensively, causing extreme desertification. Farm productivity drops by 50% ^[94] . Prices rise to levels unseen in history. Extreme food shortage in Israel causes fatal famine for country's poorest demographics. Worldwide famines claim millions of lives.	More sustainable farming methods are adopted which replenish soil health. The degraded area of arable land is reduced from its current standing of 85%. Increased productivity occurs in some areas while desertification intensifies in others. Total food supply loss is variable, ranging from 10-50% ^[94] .	Ethiopia's already degraded soils are continued to be farmed employing unsustainable practices. Degradation intensifies and expands, resulting in extreme crop yield losses of 50% or above ^[94] .
Fertilizer Price Bump	Potash and Phosphorus resource management improves; fertilizer prices rise slowly but steadily, lifting food prices with them. Organics or other substitutes begin to take over as economically efficient alternatives. Israel suffers moderately from increasing staple food prices over time and only severely during food crises when agribusinesses raise prices as food demand spikes.	The resources necessary for fertilizer synthesis are exhausted nearly completely. Purchasing of fertilizers becomes economically inefficient for farmers. Crop yields shrink to 50-71% of their original volumes. Global food crises follow, causing extreme increases in staple food prices, famines among the global poor, including Israel. Fatalities occur in the millions.	Ethiopia continues to utilize non-input intensive farming techniques. Fertilizer price bumps affect the nation only in food crisis years when they must import grains from the global market that are subject to fertilizer prices.	Ethiopia's agricultural sector becomes more dependent on fertilizer use. Carrying capacity increases with production, then crashes as fertilizer prices become unattainably high. Food shortages prevail on a scale unknown.

Threats	Israel		Ethiopia	
	Mild Scenario with Governmental and Institutional Intervention	Extreme Scenario Lacking Institutional Relief	Mild Scenario with Governmental and Institutional Intervention	Extreme Scenario Lacking Institutional Relief
Inadequate Distribution Network	N/A	N/A	Government sponsored projects and those run by outside investors help to connect the nation through an extensive railway system. Roadways continue to be insufficient means for reaching rural populations. During famines, food aid fails to reach the most obscure demographics, increasing the amount of fatalities only in extreme situations of urgency. Some aid from organizations like the Red Cross may assuage this issue through air transport and additional aid delivery.	Railways fail to be built. Roadways are inefficient distribution networks for food aid. Large sections of the population are unreachable in time to save. Future famines have devastating effect on rural populations.

Threats	Israel		Ethiopia	
	Mild Scenario with Governmental and Institutional Intervention	Extreme Scenario Lacking Institutional Relief	Mild Scenario with Governmental and Institutional Intervention	Extreme Scenario Lacking Institutional Relief
Climate Anomalies (Floods, Winter Storms, etc.)	Continued agricultural research brings winter resistant and other harsh-climate resistant varieties of crops which partially withstand harsh weather events. Some more extreme events occur; price volatility persists. Food prices double during anomaly years.	Technological innovation is unsuccessful in producing varieties able to withstand harsh weather events. Climatic anomalies continue into the future, causing prices to increase by factors of 2-4.	Farm modernization through Ethiopian and international programs help protect the productive lands, in part, from extreme weather events. Regional events nonetheless reduce or wipe out certain harvests. Food prices double. Mild to moderate famine ensues.	Ethiopia's agriculture does nothing to prepare against harsh climatic swings and volatility. Extreme events have devastating effects on regional yields. Food shortages occur, causing prices to increase by a factor of 4. Massive, severe famines ensue.

Conclusion

These threats, both mild and severe, will take serious tolls on the nations' economies, hunger levels, poverty levels, and social and political stability. There is evidence that such effects can have extreme transformative effects to societies. Broad conflicts emerge in times of scarcity, and they rarely stay within their borders. The Pentagon's 2014 Quadrennial Defense Review even admits that "Competition for resources, including energy and water, will worsen tensions in the coming years and could escalate regional confrontations into broader conflicts – particularly in fragile states." [95] It remains to be seen how the international community will respond to shortages that destabilize governments and societies as a whole. Hopefully, the crises that come will supply ample time to form alternative plans and sustainable alternatives. Cuba was able to rise from the ashes, given their ample supply of rain and good soil; perhaps other nations will be able to as well.

Then again, maybe not. In a nation where their soil is completely degraded, years are necessary for remediation. Many of the threats have long lasting or irreversible effects. Once our phosphorus and potassium reserves (the elements necessary for synthesizing fertilizer) are exhausted, the additional productivity gleaned from them also disappears forever. After a massive drought induced famine, the abandoned fields will not suddenly explode into productivity. It might be that the coming

food crisis will be much like climate change in that we cannot avoid the worst of it without acting decades in advance. It might be that when disaster strikes, all options have run out for the future's generations. They will be forced to face the collective inaction that gripped the generation before us. For now, we face an uncertain future.

Research could be executed in a few fields which would help immensely. I believe intense examination of past food crises' causes, effects, and repercussions will help provide a clearer image of what is to come. Sociological research exploring the nature of humanity's preference to reactivity rather than proactivity would also be helpful. Should the conclusion be made that the coming food crises do indeed require action decades in advance of their arrival, it could be that this global dilemma is only avoidable through the spurring of societal motivation. Until we decide to act collectively, we may collectively suffer.

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