Consilience: The Journal of Sustainable Development
Vol. 3, Iss. 1 (2010), Pp. 117–138

The Food Crisis in Ethiopia & Egypt: Contrasting Hydrological & Economic Barriers to Development

Leah Stokes
School of International and Public Affairs
Columbia University, New York, NY, USA*

A. Tianna Scozzaro
School of International and Public Affairs
Columbia University, New York, NY, USA†

Jennifer Haller
School of International and Public Affairs
Columbia University, New York, NY, USA‡

Abstract

Water scarcity is often underemphasized in analyses of the global food crisis. Ethiopia and Egypt are compared in order to understand the differences between physical and economic water scarcity and their impacts on food security. Water availability in Egypt is low compared with Ethiopia; however, irrigation is widely practiced in Egypt, supporting a variety of crops, including water intensive species, and ensuring food security. In Ethiopia, lack of water infrastructure and a lack of institutional capacity limit food security. In addition, Ethiopia's GDP is strongly linked to agricultural exports. As a result, Ethiopia's economy is tightly coupled with rainfall. The adaptation Egypt has implemented to overcome physical water scarcity is in stark contrast with the lack of institutional capacity Ethiopia has to harness its water abundance. The result is chronic food insecurity in Ethiopia, which Egypt has been able to overcome, at least in the short term. Climate change and population growth may pose additional stressors for water availability in both countries. Solutions to overcome food insecurity in Ethiopia include irrigation, growing less water intensive crops, improving governance and increasing access to climate information.

Keywords: Egypt; Ethiopia; food security; water scarcity; irrigation.

1. Introduction

Current global food crisis analyses do not adequately consider water availability's effect on food production and supply.[1] According to the United Nations (UN), the

---

* email: lcs2135@columbia.edu
† email: as3463@columbia.edu
‡ email: jah2180@columbia.edu

recent world food crisis caused an 80% jump in food prices from 2005 to 2008.[2] The global food crisis particularly affected Africa, exacerbating limited purchasing power within Sub-Saharan countries. The underlying causes of food scarcity are intricate, complex and controversial; scholars currently attribute the most recent price spike to bio-fuel production, changing diets in Asia, drought (particularly in Australia), high farm input prices due to commodity price fluctuations and financial speculation.[3] However, regional hydrological conditions clearly exacerbated the recent crisis.[4] Although it is not always considered a key issue in food crises, regional droughts have important implications for water availability, and consequentially, food security. In recent years, climate change may have intensified regional droughts by increasing the extreme weather events' intensity and frequency.[5] In Africa, existing water shortages combined with water management problems worsened the effects of last year's global food crisis. These water shortages reflect two major underlying problems: economic water scarcity and physical water scarcity.

The International Water Management Institute (IWMI) defines physical water scarcity as water resource development that "is approaching or has exceeded sustainable limits."[6] Physical water scarcity is not just an issue of supply, but critically, the measure evaluates use. A nation classified under physical water scarcity withdraws and uses more than 75% of available surface water. Physical water scarcity is what we classically think of as water scarcity: lack of adequate supply. However, water scarcity also occurs when institutional and economic capacity is inadequate. This problem, termed economic water scarcity, is defined as "human, institutional and financial capital limit[ing] access to water even though water in nature is available locally to meet human demands."[7] Under this circumstance, which typically results in high levels of malnutrition, less than 25% of locally available fresh water is utilized.

The effects of the global food crisis are closely interlinked with water scarcity. In Africa, water availability for agricultural purposes is constrained by these two different forms of water scarcity. Using a case study approach, we compare Egypt, a country facing physical water scarcity, with Ethiopia, a country facing economic water scarcity, to examine the mechanisms influencing food availability in both these countries. As Table 1 shows, Egypt's combination of low water availability with high withdrawal rates leads to strong physical water scarcity. In contrast, Ethiopia's relatively high water availability is paired with dramatically low water withdrawal rates, rendering an astonishing 2% water withdrawal, a pattern indicative of economic water scarcity.

To demonstrate how both forms of scarcity interact with food availability, we compare Egypt and Ethiopia in three main ways. First, we use the water requirements satisfaction index (WRSI) to compare physical water resource availability. The WRSI is a crop performance indicator based on the availability of water during a growing season; a WRSI of 100 indicates growing conditions with no

[1] IWMI 2008
[2] Faiola, 2008
[3] Heady and Fan 2008
[4] IWMI 2008
[5] IPCC 2007
[6] Molden et al. 2007
[7] Molden et al. 2007

	Total renewable water resources (km³)	Irrigation water requirements (km³)	Water requirement ratio (%)	Water withdrawal	
				agriculture (km³)	as % of renewable water resources
Egypt	58.3	28.43	53%	53.85	92% - Physical Water Scarcity
Ethiopia	110	0.56	22%	2.47	2% - Economic Water Scarcity

Table 1: Water Withdrawal and Water Requirements
(Source: FAO 2008; See Aquastat data for 2000).

water deficit.[8] Next, agricultural indicators including irrigation, water-storage infrastructure and crop choices are examined. Finally, economic and institutional indicators are assessed to determine how policies can exacerbate or mitigate national water scarcity and food shortages.

Egypt has long served as a flagship for effective water resource management; due to arid conditions and low precipitation levels, the Nile River remains the country's primary surface water source. Water availability produces high population density along this river basin; more than 99% of the population is concentrated in 5.5% of the land.[9] Agricultural land use parallels these population patterns. Due to physical water scarcity, agriculture in Egypt depends on smart irrigation techniques and effective water management to maintain agriculture throughout the country.

Water resource management techniques in Ethiopia sharply contrast with Egypt, due to differences in both natural systems and management strategies. Ethiopia has high annual precipitation in its eastern highland region, nutrient rich soil, and high agricultural potential throughout the country. Although abundant water supply earned Ethiopia the term "water tower of Eastern Africa," the Ethiopian population remains without proper water infrastructure.[10] In Ethiopia, economic water scarcity could be alleviated through the implementation of appropriate irrigation and water storage techniques. Egypt and Ethiopia present contrasting case studies because they present extremes; Egypt is the second most irrigated country in the world, while Ethiopia is one of the least irrigated countries. Through this in-depth study, we can better understand similar cases around the globe. We argue the key difference in food security between Egypt and Ethiopia results from physical versus economic water scarcity profiles. This case is made in three segments: water availability, agricultural techniques, including irrigation and crop choice, and economic and institutional capacity.

2. Water Availability

The United States Geological Survey (USGS) developed the water requirements satisfaction index (WRSI) to incorporate water needs into projections for crop growth. The WRSI is calculated using actual evapotranspiration (AET), potential

[8] Senay 2004
[9] Ghassemi 2005
[10] Awulachew et al, 2005

evapotranspirtation (PET), and crop coefficients (K_c).[11] Actual evapotranspiration is the actual amount of moisture drawn from the soil, which can be limited by water availability; it is a measure of water removal from soil evaporation and transpiration from plants. Potential evaportranspiration, on the other hand, is the potential amount of moisture that could be drawn from the soil assuming an adequate amount of water is available. The crop coefficient, which varies by both crop and by growing period, is calculated from the ratio of evapotranspiration observed for a crop compared to that of a reference crop under the same conditions.[12] In other words, a crop coefficient compares the amount of water being drawn out of the soil from a particular crop as compared to a baseline. A crop with a higher coefficient needs more water than one with a lower number. Illustrating this concept further, Figure 1 plots maximum crop coefficients across both Egypt and Ethiopia. This information is useful to identify which crops could be productive in a certain area according to its water availability.

Since a WRSI of 100 indicates optimal growing conditions without a water deficit, we set the WRSI equal to 100 and calculated the necessary crop coefficients to determine ideal crops for Ethiopia and Egypt.[13] Regions capable of supporting higher crop coefficients are less arid and will likely require less irrigation to maintain healthy crop yields. In contrast, regions that are only able to support low crop coefficients are dryer regions and will likely require water management or irrigation. AET and PET values were obtained for Egypt and Ethiopia in the form of spatial data from the USGS Global GIS Database for Africa.[14] Thereafter, maximum necessary crop coefficients for no water deficit were calculated for cities in both Ethiopia and Egypt for each season (Figure 1). Precipitation data and cropland type were obtained from the USGS Global GIS database (Figure 4 and 5, respectively).[15] All maps and tables were produced for this article.

Using the Food and Agriculture Organization's (FAO) CROPWAT and CLIMWAT programs, we calculated crop coefficients for common food and biofuel crops grown in Egypt (cotton and maize) and Ethiopia (sugarcane and potatoes). Crop choices were based on data obtained from the World Bank and the Central Intelligence Agency (CIA) on major agricultural crops and exports. We then determined crop irrigation requirements for Egypt and Ethiopia (Figures 2 and 3, respectively.) Based solely on evapotranspiration data, Ethiopia is able to produce more crops with higher water demands than Egypt (Figure 1). This likely occurs because Ethiopia receives significantly more precipitation than Egypt (Figure 4).

While Ethiopia receives little annual precipitation along its northern and eastern coastal regions, the central and western part of the country can have high rainfalls of up to 2000 mm annually (Figure 4). This spatial rain distribution, in which the Western Ethiopia's highlands receive precipitation while the low lands have great variability in rainfall year over year, is often linked to fluctuations in food availability and regional droughts.[16] Ethiopia also has significant seasonal fluctuations in rainfall.

---

[11] $WRSI = AET/(PET * K_c) *100$
[12] Senay 2004
[13] $100 = AET/(PET * K_c) * 100 \Rightarrow K_c = AET/PET$
[14] Hearn et al. 2001
[15] Hearn et al. 2001
[16] Erkineh 2007: 31-34

Between June and November, the southwest portion of Ethiopia should be capable of supporting crops with crop coefficients of between .844 and 1.098. In this eastern part of Ethiopia, irrigation becomes more necessary due to annual fluctuations in rainfall.

In contrast, some areas in Egypt, including Siwa and Aswan, receive no annual precipitation. Since Egypt receives less than 250 mm of rain annually, it is classified as arid. Egypt is not able to support any crops with crop coefficients above .305 and .573 without irrigation. In fact, the majority of Egypt is unable to support any crops throughout the year without irrigation, which is especially true through the Sahara desert. This high usage profile makes Egypt suffer from physical water scarcity. In order to compensate for this lack of precipitation, Egypt employs irrigation techniques to utilize water from the Nile River. Sustaining corn cultivation in Alexandria, for example, requires almost 600 mm of irrigation water annually. Cotton cultivation in Alexandria requires slightly more irrigation water, approximately 731 mm (Figure 2); cotton's significant water needs are likely one reason that cotton is being grown less within Egypt in recent years.

As shown in Figure 5, Egypt's agriculture is primarily concentrated around the Nile River, with a few patches of dry cropland to the south and west. Since these patches are located in the desert, they are likely oases concentrated around a spring or similar water source. Agriculture in Ethiopia, on the other hand, occurs on mostly dry and wooded cropland. Since very little cropland in Ethiopia is irrigated, agricultural yields are solely dependent on precipitation, termed 'rain-fed agriculture'. As indicated by the calculated irrigation requirements displayed in Figure 1, areas in the southwestern portion of Ethiopia receiving sufficient rainfall are capable of supporting potato cultivation with little or no irrigation. We see this in Figure 3, which shows sugarcane cultivation in Ethiopia requires significantly more water and would necessitate irrigation, even in areas with high precipitation rates. In contrast, Figure 3 highlights that potatoes would not require irrigation in 3 of the 4 areas examined.

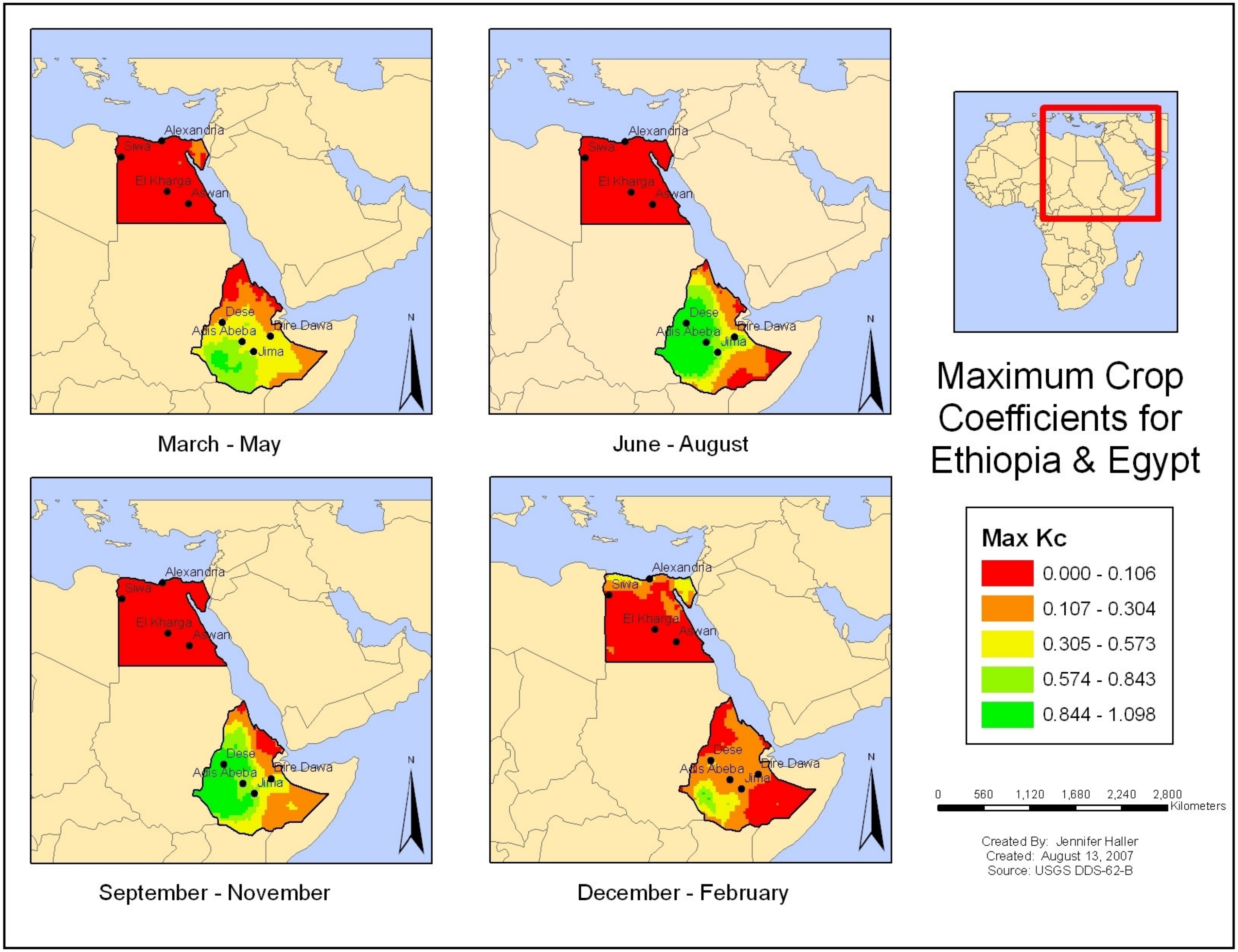

Figure 1: Maximum Crop Coefficients for No Water Deficiency in Ethiopia and Egypt.

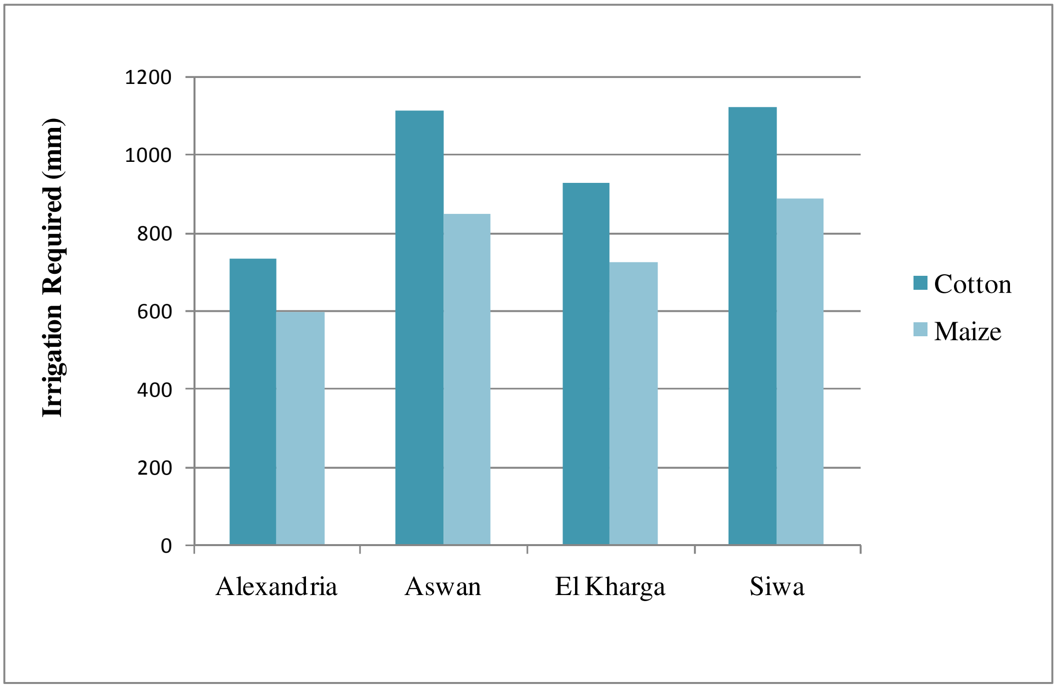

Figure 2: Irrigation Water Requirements for Cotton and Maize in Egypt.

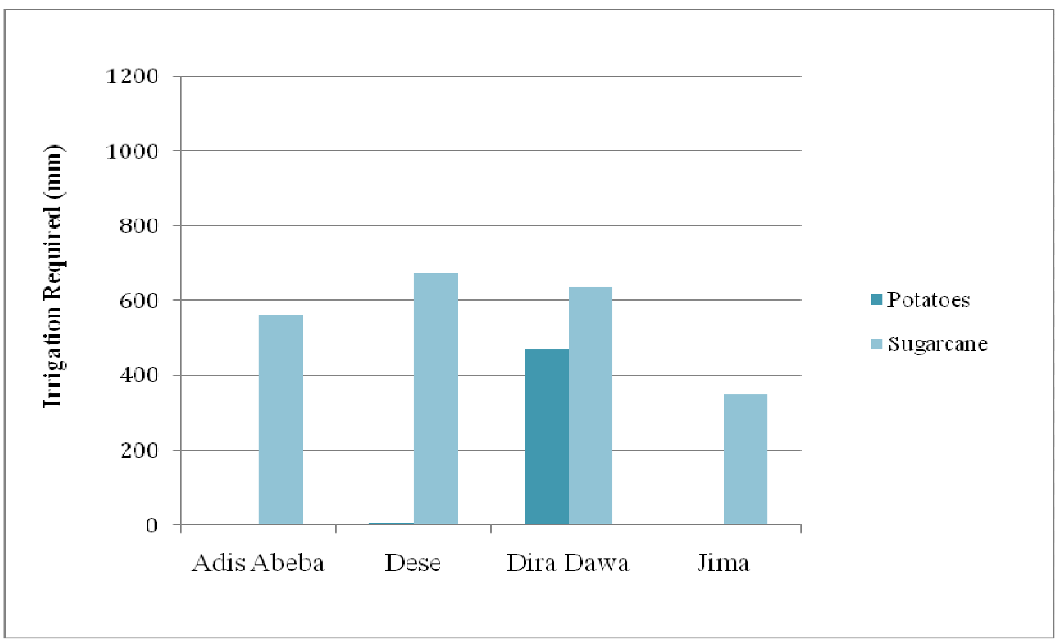

Figure 3: Irrigation Water Requirements for Potatoes and Sugarcane in Ethiopia.

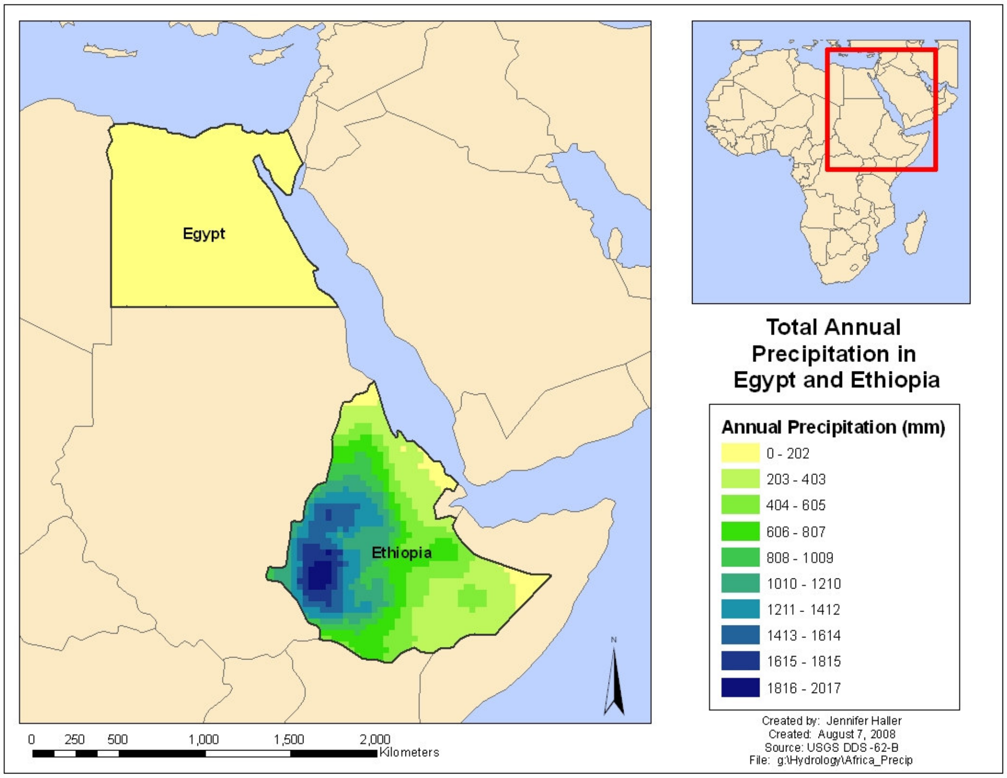

Figure 4: Annual Precipitation (mm) in Ethiopia and Egypt.

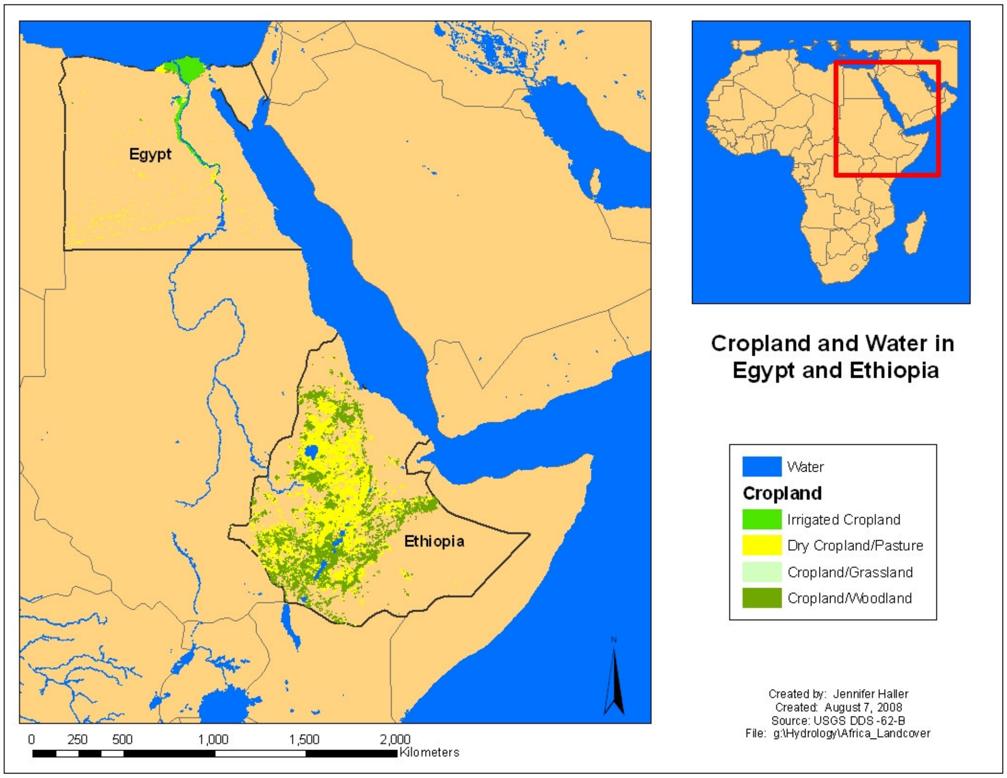

Figure 5: Cropland and Water Cover in Egypt and Ethiopia.

3. Agriculture

3.1 Irrigation

Agriculture technologies vary greatly by country and by region, depending on available resources. There are a host of different strategies, techniques, and systems to apply to agriculture within Ethiopia and Egypt; both countries take unique approaches based on their physical geography and economic resources. Through examining land use, cultivation strategies, crop choices, irrigation and rain harvesting techniques in both countries, it is clear that Egypt has effectively coped with physical water scarcity through successful irrigation implementation. In contrast, Ethiopia has not adopted irrigation and storage techniques on any significant scale, and is therefore struggling with economic water scarcity.

3.1.1 Irrigation in Egypt

Egypt exemplifies effective land use through highly efficient irrigation along the Nile River Basin. These irrigation practices date back as far as the 6th millennium B.C.E. in Egypt, when farmers grew barley in areas of insufficient rainfall. Today, through the use of drip, canal and flood irrigation methods, Egypt ranks as the second most irrigated country in the world, using highly efficient methods.[17] Since virtually all the cropland in Egypt is efficiently irrigated, the country is able to reduce dependence on environmental stochasticity, such as long dry spells or drought. Egyptian irrigation efficiency is estimated to be between 50 to 87%; this irrigation efficiency is a ratio of the amount that useful water in the soil to the total amount of water delivered.[18] Drip irrigation in the remote desert regions has the highest efficiency with minimal loss through evaporation, while flood and canal irrigation along the river yields about 82% efficiency.[19] Techniques such as irrigation scheduling and conservation tillage contribute to the high irrigation efficiency by reducing runoff and soil erosion. The Egyptian government encourages the use of these techniques through policy incentives such as water prices, allotments and subsidies for improving irrigation methods, and the removal of output price distortions that favor crops with large water requirements in water-short regions.[20] Although Egypt has comparatively less arable and permanent cropland, farmers have been able to use these techniques to achieve high productivity (Figure 5).[21] As a result, crops can be grown year-round.

Dams and branch canals are another means to improve irrigation technology. Egypt receives 55.6 cubic kilometers of water from Lake Nassar in the southern portion of the Nile above the Aswan Dam.[22] However, dams such as these have their flaws; the Aswan Dam region creates complicated downstream usage, with highly saline agricultural drainage.

---

[17] Currently 99.94% of Egypt is irrigated. CIA 2008.
[18] Oosterbaan 1999: 21
[19] Oosterbaan 1999: 21
[20] Wichelns 1999: 543
[21] Egypts arable land is of 3,291,000 ha. CIA 2008.
[22] IWMI 47

Despite these innovations, Egypt will soon face a water crisis. Hydrologists show that the total water use in Egypt is at the brink of surpassing the actual water availability. In 2000, water withdrawal was already at 92% of renewable capacity, in contrast to a mere 2% in Ethiopia, illustrating the unsustainability of Egypt's water use. [23] With already high efficiency, Egyptian farmers will face serious challenges to improve upon the well-established agricultural techniques and strategies. This problem is exacerbated by an above average population growth rate (Table 3) and rapidly increasing food prices, driven by the global food crisis.[24] Egypt needs to decide whether it can cultivate more crops to feed the expanding population while still conserving water supply for other means. Alternatively, the nation may choose to import more foodstuffs, putting the economy at risk to escalating food prices. However, if oil rises in price alongside other commodities, Egypt will retain its purchasing power for food, despite rapid inflation. The change in commodity prices since 2008, however, suggests forecasting is unpredictable.

Looking ahead, agricultural production processes will likely expand in their intensity, confronting industrial and domestic sectors' demands for water access. Unlike Ethiopia, in Egypt rainwater storage and catchment are not a viable alternative, due to low annual precipitation. Proposed solutions include increased desalinization, shifts to less water intensive and saline resistant crops, and conservation tillage. Along these lines, the World Bank is currently developing a pipeline to pump water from the Nile River to the Sahara Desert's more arid regions to increase agriculture production.[25]

3.1.2 Irrigation in Ethiopia

In stark contrast to Egypt, irrigation is virtually absent in Ethiopia, representing only 2.46% of agricultural production ().[26] Recently, increasingly frequent dry spells and droughts in the region leave farmers without means to water their crops. In 2008, Ethiopia suffered from a severe food shortage due to a crop failure. These problems are exacerbated by lack of irrigation due to the current system's dependence on animal drawn tillage (plough and draught techniques), which causes low water efficiencies and increase soil erosion.[27] [28]

---

[23] FAO 2008: Figure 8
[24] Egypt's growth rate is 1.9%; World Bank, The Little Green Data Book, 2007
[25] IAEA 2007
[26] CIA 2008
[27] Gebregziabher et al. 2005
[28] Temesgen 2000

	Egypt	Ethiopia
Irrigation (out of 164)	# 2 – 99.94 %	# 126 – 2.46 %
Agriculture as total percentage of fresh water withdrawal	86%	94%
Arable land and permanent cropland (out of 148)	# 65 – 3,291 thousand hectares 2.92%	# 24 – 10,728 thousand hectares 10.01%
Arable land - per capita (1 million) (out of 148)	# 142 – 42.461 thousand hectares	# 104 - 146.852 thousand hectares
Fertilizer consumption (100 grams/ha arable land)	4,322	151
Agriculture Products	cotton, rice, corn, wheat, beans, fruits, vegetables; cattle, water buffalo, sheep, goats	cereals, pulses, coffee, oilseed, sugarcane, potatoes, qat; hides, cattle, sheep, goats
Commodity imports	machinery and equipment, foodstuffs, chemicals, wood products, fuels	food and live animals, petroleum and petroleum products, chemicals, machinery, motor vehicles, cereals, textiles
Commodity exports	crude oil and petroleum products, cotton, textiles, metal products, chemicals	coffee, qat, gold, leather products, live animals, oilseeds

Table 2: Agriculture and Irrigation Statistics (Source: CIA 2008).

Large and medium scale irrigation, defined as systems more than 200 ha[3], comprise a large portion of the irrigated lands. These systems are well understood, and more often incorporated into international development strategies.[29] Yet large-scale irrigated agriculture is often not part of the food provision for the country, and thus does not increase food security. One example is a recently funded ethanol program, for which 18,000 ha of land will be cultivated for sugarcane ethanol production. BDFC Ethiopia Industry PLC, a subsidiary of the US based B&D Food Corporation, is orchestrating the project with a $33 million budget, on a site initially designated for an irrigation scheme along the Beles River.[30] Sugarcane production is a valuable contributor to national GDP, showing that irrigation is being viewed as a tool for economic development. On the one hand, this change towards increased export crops may help to raise the country's GDP, potentially increasing the country's purchasing power for food, both imported and domestic. This argument sees food insecurity as an economic, distributional problem rather than a production problem.[31]

However, this program will not directly alleviate the food insecurity for the nation's impoverished rural communities. Expanding irrigation to biofuels at the expense of food crops could exacerbate Ethiopia's existing food insecurity. Focusing

29 Awulachew et al. 2005: 13
30 Zenebe 2008
31 Sen 1982

on irrigation for biofuels and export crops may distract attention from ensuring locally consumed food crops are viable during droughts, potential drawing land and economic resources away from food production.[32] In addition, there could be secondary economic effects exerted through commodity price fluctuations. Finally, the primary producers of biofuels may not see a large part of the good's value due to market structures limiting economic development.[33] For this reason, Ethiopia's policy decisions on irrigation for export sugarcane may have unintended economic consequences and should be considered thoroughly within the context of the country's economic policies.

Most of the rural population depends on rain-fed agriculture, resulting in high vulnerability. Through implementing small scale irrigation systems and increasing storage capacity, these farming communities would have the tools required for effective subsistence agriculture alongside reliable livelihoods. Water resources managers suggest that effective water harvesting systems is more important than irrigation for promoting highly productive agriculture in Ethiopia.[34] By improving upon the rain-fed schemes, such as in-situ basins and pits, implementing technologies on a small-scale and improved land use, the agriculture sector has the potential to double rain-fed crop yield in the next 10-15 years.[35] These ponds or ditches provide sufficient water to sustain a 0.5 ha family vegetable garden; hence they are a successful mechanism to overcome the recurrent erratic rainfall and dry spell conditions which have historically led to wide-spread crop failure and famine in Ethiopia.[36]

Modern micro irrigation technologies that lift, convey and apply irrigation waters on an individual farm scale can also be very effective in creating water autonomy for individual farmers, while traditional irrigation and water management strategies could coordinate canal usage on a community level. Micro-irrigation implementation is not uniformly understood in Ethiopia, so gathering accurate and comprehensive data on current practices is difficult due to lack of infrastructure. In many cases, investments in agriculture technologies require simultaneous investment in other infrastructure. Thus, effective investment in water technologies such as bucket and drip irrigation and small sprinkler systems would require complementary investment in roads and communication. To implement these techniques on a larger scale, the stored rainwater could be incorporated into irrigation systems to pump the water from the catchment basin to the plants for efficient water application. Increasing the use of effective water harvest, storage and distribution methods is fundamental to improving food security in Ethiopia.

3.2 Crops

Crop choice depends on a variety of factors, and does not necessarily reflect water scarcity limits. Although Ethiopia's first and second most highly cultivated crops, cereals and pulses (legumes), are largely for local consumption, coffee is the

[32] Dufey, 2006: 48-49
[33] Dufey 2006: 48
[34] Awulachew et al. 2005: 22
[35] Awulachew et al. 2005: 24
[36] Awulachew et al. 2005: 24

third most common crop. As an export crop, coffee is a critical component of the Ethiopia economy, accounting for $350 million in exports in 2006.[37] Ethiopian farmers, however, face a challenge; since coffee prices are highly variable, many farmers have turned to the widely illegal drug, qat, to increase income.[38]

In Egypt, cotton has been grown historically for generations. However, this crop requires significant pesticide and water inputs, both using large quantities of water and making water re-use within the system less likely. Cotton prices have also been variable in the past three years, reducing the amount that Egypt can garner from the crop. Nevertheless, the industry employs over one million people and generates about $1.25 bn USD annually in export revenue, making it an important part of the Egyptian economy.[39]

Fertilizer consumption also points to underlying differences in financial capacity. In wealthier Egypt, fertilizer use is widespread and extremely high, at four times the world's average fertilizer use. Fertilizer use greatly increases Egypt's capacity to grow crops, despite arid conditions and poor soil quality. In contrast, Ethiopia, with its limited GDP, uses only around 10% of the worldwide average fertilizer use.[40] Again, in this case, Ethiopia's lack of economic and institutional capacity is limiting crop yields.

Despite this reality, Ethiopia has great potential for agricultural development, with three times as much arable land as Egypt. Water sources are also abundant in Ethiopia with its 12 river basins in Blue Nile's headwaters and tremendous groundwater potential.[41] Farmers are currently only cultivating 40% of potential cropland and are relying on small-scale rain-fed agriculture and livestock. Thus, Ethiopia represents significant potential for agricultural development, which can be utilized to secure the food supply or to generate income through biofuel cultivation or export crops. Farmers that simultaneously use both on a small scale could ensure subsistence and livlihoods. Presently, Ethiopia is facing a serious challenge; with increasing demand due to population growth, serious drought, and volatile global food prices, the region will need to increase national food production in order to alleviate household food insecurity.

4. Institutional and economic capacity

4.1 Economic capacity

As the International Water Management Institute argues, the state plays a central role in ensuring effective water management, since, ultimately, water is a public good

---

[37] CIA 2008
[38] CIA 2008
[39] Howell 2004
[40] CIA 2008. See FAO 2008: Per Aquastat for the year 2000, Egypt consumes around 432,200 grams per hectare of arable land. Ethiopia uses a mere 15,100 grams per hectare of arable land.
[41] FAO 2008: Per Aquastat for the year 2000, Ethiopia's 12 river basins account for 122 billion m^3 of water, and there is an estimated 2.6 billion m^3 in groundwater potential in the country.

that must be managed by the government.[42] In Ethiopia, economic capacity severely hampers food production. During years with sufficient rainfall, GDP grows, since agriculture accounts for 60% of total exports and almost half of GDP. Thus, GDP growth is significantly correlated with rains.[43] For example, from 2004 to 2007, average rainfall patterns supported good agricultural yields and GDP increased.

However, in years of drought, the opposite pattern is witnessed with drastic consequences; in 2003, a severe drought caused GDP to drop by 3.3%.[44] Again, in 2008, severe drought in Ethiopia's eastern region led to crop failures and widespread food insecurity;[45] early projections for 2009 indicate this trend may continue.[46] As this illustrates, drought compounds food security challenges in Ethiopia; yields are insufficient to feed the population and, with a decline in GDP, the country's purchasing power also decreases. Since Ethiopia's largest imports are foodstuffs and live animals, its ability to purchase essential food to make up the shortfall can decline precipitously in periods of drought.

With rising food prices Ethiopia's purchasing power declined even further, creating large shortfalls in food in the summer of 2008. Rising commodity prices can lead to inflated food prices within the country, even compared to world prices, as was witnessed in 2008.[47] Indeed, one economic study that used data from 1989 to 1995 found rainfall a highly significant shock reducing consumption patterns within the country.[48] Thus, Ethiopia often relies on food aid, despite its good agricultural capacity and the country's growth is highly vulnerable to climate shocks.[49]

In contrast, government liberalization efforts in Egypt have increased growth significantly since 2005; GDP grew 5% in 2005 and 2006, and experienced an even more impressive growth of 7% in 2007.[50] Since oil and petroleum products are the country's primary export, it is likely that strong growth will continue in Egypt in the foreseeable future, depending on commodity price fluctuations. A strong GDP increases Egypt's ability to cope with physical water scarcity and import food when necessary, even as food prices fluctuate internationally. In fact, foodstuffs are the most important import to Egypt, after machinery and equipment.[51] Even in the face of rising food prices, Egypt, unlike Ethiopia, will likely be able to continue to purchase food in poor yield years since its main economic driver is not the agricultural sector. Nevertheless, Egypt could benefit from adopting a comprehensive development strategy, which considers long-term sustainability of water access and, thereby, access to food.

4.2 Institutional capacity and policies

[42] This view has been disputed recently, with some arguing private management of water resources may be more efficient than government management. This issue speaks to human rights and economic efficiency challenges. IWMI 2007

[43] World Bank 2006, as cited in Erkineh 2007

[44] CIA 2008

[45] UN OCHA 2008

[46] UN OCHA 2009

[47] UN OCHA 2008

[48] Dercon 2006

[49] Erkineh 2007: 31

[50] CIA 2008

[51] CIA 2008

During the summer of 2008, Ethiopia was in the midst of a severe drought, which led to significant crop failures, putting 4.6 million people in need of food aid.[52] Indeed, Ethiopia has relied on food aid in some capacity for nearly every year since the 1970s.[53] Although the shortage of crops locally is a key part of the equation, the rapid increase in global food prices in recent years has severely hampered import capacity. According to the UN's emergency relief coordinator, John Holmes, lack of government capacity and capital limited Ethiopia's ability to respond to this crisis.[54] For example, in June 2008, government cereal stocks could only cover food needs for that month, yet food was required until September 2008. As this illustrates, lack of adequate planning and grain reserves are important driver of Ethiopia's continual bouts with severe food insecurity and famine.[55]

At the same time, the Ethiopia government has instituted strong early warning policies, with success during the 2003 famine. Over the past 15 years, the Ethiopian government has worked through its Disaster Prevention and Preparedness Agency to address the root causes behind chronic food insecurity. This program supports population movements to more productive regions, employs an early warning system for droughts and provides emergency food relief when the rains fail.[56] Although almost 25% of the country's population needed food aid after the 2002 drought led to widespread crop failures, the government's early warning climate forecasting system, coupled with strong governmental agencies focused on disaster prevention, helped ensure adequate food reached people at the appropriate time.[57] This example suggests coordinated federal policy focused on forecasting droughts may be an important, short-term solution to mitigate some of the effects of climate variability. This information could also be adapted to a local level, supporting better forecasting for farmers.[58] However, longer-term food security challenges, including population pressures and climate change mean supplementary policies are also necessary.

In part, Ethiopia's high population growth rate is impeding food security. The world's average annual population growth rate from 1990 to 2005 was 1.4%; Sub-Saharan Africa averaged 2.5%, and Ethiopia averaged 2.2%. Egypt's growth rate is slightly more moderate at 1.9% (Figure 5).[59] If such high population growth is unmatched by high economic growth, food insecurity could remain a chronic challenge for generations. Climate variability is a secondary long-term problem that is likely to increase under climate change, making Ethiopian food security more vulnerable. Adaptation to climate change in Ethiopia may involve switching towards less water intensive crops, implementing crop insurance and building water storage capacity.[60]

[52] Rice 2008
[53] Erkineh 2007: 32
[54] Rice 2008
[55] White 2005
[56] Erkineh 2007: 33-36
[57] Erkineh 2007: 37-39
[58] Erkineh 2007: 44
[59] World Bank, The Little Green Data Book, 2007
[60] Paavola & Adger, 2006

	Egypt	Ethiopia
Population	81,713,517	78,254,090
Population growth, 1990–2005. (World average = 1.4%).	1.9%	2.2%
GDP (2007)	$127.9 billion	$19.4 billion
Per capita	$5,500	$800
Agriculture as percentage of GDP	13.8%	47%
Human Development Index		
Human Poverty Index (out of 148)	# 61	# 4
People without access to an improved water source (%) (out of 125)	# 119 - 2%	# 1 - 78%
Corruption Perception Index		
Six year average (2002-2007)	3.25	2.55
Ranking, 2007 (out of 179)	# 105	# 138

Table 3: Economic and Institutional Indicators (Sources: *GDP* – CIA 2008; *Human Development Index* – UNDP 2007; *Corruption Perception Index* – Transparency International, 2007.

In part, there is hope that these reforms will play out in Ethiopia in the near future. According to the World Bank's Government Effectiveness Indicator, one of several governance indicators tracked by the Bank, Ethiopia has shown a significant upward trend in government effectiveness in the past 10 years.[61] Essentially, this measure signifies that a wide-breadth of stakeholders believe that Ethiopia's policy formulation and public services are improving. Although Ethiopia lags behind Egypt in all six World Governance Indicators, the gap is relatively small, and appears to be closing, because of relative improvements in Ethiopia.[62] This reality may bode well for the country's ability to manage its ongoing food security challenges. Nevertheless, significant gains are necessary to attain real progress in poverty reduction. Presently a mere 22% of Ethiopians have access to an improved water source, making the country the highest ranked for non-attainment on this Human Development Indicator (Table 3).[63] In addition, malnutrition remains a chronic problem; 46% of the population is malnourished, consuming a mere 1850 calories a day. In stark contrast, only 2% of the Egyptian population is malnourished.[64]

Although relatively strong governance systems exist in Egypt, physical water scarcity will challenge the country to work even more efficiently with its limited water supply. In part, the government may need to support shifts towards less water intensive crops than cotton, in order to maximize yields and ensure adequate food supply. For in place agriculture, Egypt will also need to encourage multiple-use systems, in which water outputs from one usage system become the input for the

[61] World Bank, Governance Indicators, 2008
[62] World Bank, Governance Indicators, 2008
[63] UNDP 2007
[64] World Bank, The Little Green Data Book, 2007

next system. Such a strategy is critical to maximizing water efficiency.[65] Alternatively, Egypt may continue to employ comparative advantage, and rely on trade to supply foodstuffs. This solution has its obvious weakness, as demonstrated by the variable food prices of Summer 2008; however, Egypt's rapid GDP growth suggests it may be able to afford imports, at least in the short term.

4.3 Irrigation and food security policy in Ethiopia

Clearly, Ethiopia could benefit from focus on irrigation and food security policy at the national level. In marked contrast, Egypt has, to date, managed its irrigation and food availability with much more success. For this reason, we will leave Egypt aside at this point, and devote this last session to developing a few, concrete policy ideas which could support better irrigation and food security policy in Ethiopia.

The financial challenges of irrigation have hindered effective irrigation expansion in Ethiopia. Ethiopia has been the largest recipient of food aid in Africa over the past two decades, and among the largest recipients in the world.[66] US Agency for International Development (USAID) dedicated $145 million for local procurement projects for Ethiopia and three other countries in April 2009 after an ongoing crisis, which peaked in Summer 2008.[67] However, most food security aid is provided in the form of direct food shipments, seed and fertilizer; only 5% of the international aid goes toward sustainable improvements to the current agricultural system, such as irrigation investments.[68] Future funding should be strategically channeled towards irrigation for food crops. Critically, biofuel-oriented irrigation policy should be considered with reference to its impact on investments for food crop irrigation.

Additionally, most farmers in Ethiopia are not landowners; as a result, there is little individual incentive to invest in irrigation technologies. In fact, in Ethiopia, the government owns all agricultural land, and it is provided only on a lease basis. This policy limits entrepreneurship within the country.[69] Attempts to encourage practical improvements are underway, with 17% of the national government devoted to agriculture development and the start of the World Bank Ethiopian Irrigation and Drainage project.[70] This project aims to achieve sustainable agricultural output and productivity in project areas through agriculture, market and irrigation development and management. By 2015, the goal is to improve the lives of 12,600 households through the development of 20,000 hectares of ground and surface water infrastructure and establishment of 80,000 hectares in future irrigation potential. It will also provide a strategy for intensification and commercialization of national agriculture through increased irrigation efficiencies.[71]

Ethiopia's policies, however, are fundamentally challenged by climatic variability. In order to make up for periodic shortfalls in rain, Ethiopia needs to institute reforms that build capacity at the smallholder farmer level. Since agriculture plays

[65] Molden et al. 2007
[66] Little 2008: 2
[67] Gillam 2009: 1
[68] Makunike 2008
[69] CIA 2008
[70] World Bank, Ethiopia Irrigation, 2007
[71] World Bank, Ethiopia Irrigation, 2007

such a key role in the national economy, building agricultural capacity through improvements in water management is critical to reducing poverty and ensuring food security. As IWMI argues, "smallholder farmers possess the greatest unexploited potential to directly influence land and water use management."[72] Capacity building for this population includes training, improving storage capacity and ensuring equitable water access for women. Despite the fact that women produce two-thirds of the crops in developing countries, they rarely own land, or have access to the necessary water and inputs required to maximize crop yields.[73]

Index insurance based on climate forecasts could also play a critical role in supporting Ethiopia's agriculture. Essentially, index insurance establishes a relationship between climate and insurance, making payouts faster and helping to preserve farmer's assets. Quick action is important in Ethiopia, since farmers selling assets during drought remains an important component of food insecurity and long-term reliance on food aid.[74] The International Research Institute for Climate and Society (IRI) has been particularly active in this area, helping to build capacity within Malawi for drought insurance.[75] Since both these countries have limited irrigation, with high dependence on rain-fed agriculture, drought insurance is a potential policy solution for Ethiopia. These efforts are critical, since chronic food insecurity could lead to broader insecurity within the Sahelian region, eventually increasing migration and possibly conflict.[76]

5. Conclusion

Contrasting Egypt and Ethiopia's water scarcity challenges and how these problems translate in the midst of a global food crisis yields interesting results. Although, the countries share a similar population size, they differ markedly in their economy's size. As a result, more prosperous Egypt can sustain international food purchases despite soaring prices, while Ethiopia struggles in the face of droughts, increasing food costs and food shortages. Since Ethiopia's economy is strongly dependent on agricultural exports, droughts not only reduce crop yields, but also drop their GDP precipitously, which is exacerbated by the lack of irrigation infrastructure. With climate change, droughts will likely increase in frequency in this region, further hampering Ethiopia's financial capacity.[77] Clearly, capacity building is crucial to navigate these additive and synergistic problems.

A key difference between the water scarcity in Ethiopia and Egypt remains water availability; as demonstrated, Egypt lacks sufficient water, while Ethiopia maintains a relatively adequate and stable water supply but lacks the complementing infrastructure to support exploitation. Clearly, increased irrigation infrastructure will

72 Molden et al. 2007: 21
73 Molden et al. 2007
74 Erkineh 2007
75 Osgood and Warren 2007: 75-87
76 One report classified Ethiopia as a state "facing a high risk of armed conflict as a knock-on consequence of climate change." In contrast, Egypt was classified as a state "facing a high risk of political instability as a knock-on consequence of climate change." See Smith and Vivekananda 2007: 13,18-19, 22
77 IPCC 2007

play a key role in increasing Ethiopia's capacity to grow enough crops to feed its population. Grain storage is also important capacity building to guard against future food insecurity. In Egypt, on the other hand, irrigation has essentially reached its limit, and the country must now grapple with physical water scarcity in determining how foodstuffs will be provided for the growing population. These challenges are playing out in the midst of a search for energy in the form of food through biofuel cultivation. Whether either country significantly invests in biofuels as an alternative to foodstuff cultivation will play a key role in determining regional food security in the future. As this analysis shows, crop choice is a key component of food availability in both these countries. For Egypt, this choice may have particular importance, since water conservation remains critical.

Finally, institutional reforms will be necessary to ensure adequate water is available for agriculture. Reducing corruption and increasing the effectiveness of governments are key components to increasing capacity. Here, Ethiopia shows some potential for a more stable food supply in the future, as government capacity and climate monitoring have increased dramatically in the past decade. Nevertheless, there is more work necessary for Egypt and Ethiopia, as both countries attempt to navigate growing food prices in the midst of shrinking and changing water supplies worldwide.

6. Bibliography

Awalachew, S. et al. *Experience and Opportunities for Promoting Small-Scale/Micro Irrigation and Rainwater Harvesting for Food Security in Ethiopia*. Colombo: International Water Management Institute, 2005.

Central Intelligence Agency (CIA). *CIA World Factbook*. Available online at: <https://www.cia.gov/library/publications/the-world-factbook/> Last Accessed 14 August 2008.

Dercon, Stefan. "Economic reform, growth and the poor: Evidence from rural Ethiopia." *Journal of Development Economics*. 81 (2006): 1-24.

Dufey, Annie. "Biofuels production, trade and sustainable development: emerging issues." *IIED Sustainable Markets Discussion Paper*. 2 (2006): 1-57.

Erkineh, Teshome. "Food Security in Ethiopia." *Climate risk management in Africa: Learning from practice*. Ed. Molly Helmuth. Palisades, NY: International Research Institute for Climate and Society, 2007. 31-44.

Faiola, Anthony. "The New Economics of Hunger." *Washington Post*. 27 April 2008.

Food and Agriculture Organization of the United Nations (FAO). "Review of agricultural water use per country," Available online at: <http://www.fao.org/nr/water/aquastat/water_use/index.stm> Last Accessed 9 August 2008.

Gebregzaibher, Solomon et al. "Animal Drawn Tillage, the Ethiopian and plough, *marshea:* A review." *Soil and Tillage Research*. 89.2 (2006): 129-143.

Ghassemi, F. et al. *Salinisation of Land and Water Resources: Human Causes, Extent, Management and Case Studies*. Wallingford, UK: CABI, 1995.

Gillam, Carey. "Food crisis not over, US aid is key-WFP official," *Reuters*. 7 April 2009.

Heady, Derek, and Shengen Fan. *Anatomy of a Crisis: The Causes and Consequences of Surging Food Prices*. Washington, DC: International Food Policy Research Institute, December 2008.

Hearn, P. et al. *Global GIS Database: Digital Atlas of Africa 2001*, CD-ROM, United States Geological Survey.

Howell, Jeremy. "Egyptian Cotton Makers Fight to Survive," *British Broadcasting Corporation*, 7 December 2004, Available online at <http://news.bbc.co.uk/2/hi/business/4073365.stm> Last Accessed 14 August 2008.

Intergovernmental Panel on Climate Change (IPCC). *Climate Change 2007: Impacts, Adaptation, and Vulnerability. Contribution of Working Group II to the Fourth Assessment Report of the Intergovernmental Panel on Climate Change.* [Electronic version]. Cambridge, UK: Cambridge University Press, 2007.

International Atomic Energy Agency (IAEA). "Nubian Sandstone Aquifer System Project." Available online at: <http://www-naweb.iaea.org/napc/ih/Nubian/IHS_nubian.html> Last Accessed 20 April 2009.

International Water Management Institute (IWMI). "Water: The Forgotten Crisis." ScienceDaily. 14 July 2008. Available online at: <http://www.sciencedaily.com-/releases/2008/07/080710103907.htm> Last Accessed 4 August 2008.

Kaumbutho P G, Pearson R A and Simalenga T E (eds), 2000. "Empowering Farmers with Animal Traction." Proceedings of the workshop of the *Animal Traction Network for Eastern and Southern Africa* (ATNESA) held 20-24 September 1999, Mpumalanga, South Africa. 344 p.

Little, Peter. "Food Aid Dependency in Northeastern Ethiopia: Myth or Reality?" *World Development*. 36.5 (May 2008): 860-874.

Makunike, Chido. "Ethiopia offers lessons on emerging from food aid dependency". *African Agriculture*. 6 March 2008. Available online at: <http://africanagriculture.blogspot.com/2008/03/ethiopia-offers-lessons-on-emerging.html> Last Accessed 13 August 2008.

Molden, David et al. "Comprehensive Assessment of Water Management." *Water for Food, Water for Life: A Comprehensive Assessment of Water Management in Agriculture*.

London, UK: Earthscan; Colombo, Sri Lanka: International Water Management Institute, 2007. 57-89.

Oosterbaan, R. J. *Impacts of the Irrigation Improvement Projects in Egypt*. Wageningen, The Netherlands: Egyptian-Dutch Advisory Panel and International Institute for Land Reclamation and Improvement, 1999.

Osgood, Daniel and Warren, Duncan. "Drought insurance in Malawi." *Climate risk management in Africa: Learning from practice*. Ed. Molly Helmuth. Palisades, NY: International Research Institute for Climate and Society, 2007: 75-87.

Paavola J. and N.W. Adger. "Fair Adaptation to Climate Change". *Ecological Economics* 56 (2006): 594-609.

Rice, Xan. "Food crisis: Ethiopia appeals for urgent aid after crop failure". Guardian. 13 June 2008.

Sen, Amartya. *Poverty and Famines*. Oxford: Oxford University Press, 1982: 1-257.

Senay, Gabriel. *Water Requirement Satisfaction Index*. Oct. 2004. United States Geologic Survey. Available online at: <http://earlywarning.usgs.gov/CentralAmerica/dailywrsirm.php> Last Accessed 13 August 2008.

Smith, Dan and Janani Vivekananda. *A Climate of Conflict: The Link Between Climate Change, Peace and War*. London: International Alert, 2007.

United Nations Development Program (UNDP). *The Human Poverty Index 2007*. Available online at <http://hdr.undp.org/en/statistics/indices/hpi/> Last Accessed 14 August 2008.

United Nations Office for the Coordination of Humanitarian Affairs (UN OCHA). "Situation Report: Drought/Food Crisis in Ethiopia." *4 November 2008*. Available online at: <http://ochaonline.un.org/ethiopia/SituationReports/tabid/2943/language/en-US/Default.aspx> Last Accessed on 1 March 2009.

United Nations Office for the Coordination of Humanitarian Affairs (UN OCHA). "Situation Report: Drought/Food Crisis in Ethiopia." 20 June 2008. Available online at: <http://ochaonline.un.org/ethiopia/SituationReports/tabid/2943/language/en-US/Default.aspx> Last Accessed on 20 April 2009.

White, Philip. "War and food security in Eritrea and Ethiopia, 1998–2000". *Disasters*. 29.1 (2005): 92-113.

Wichelns, Dennis. "Economic Efficiency and Irrigation Water Policy with an Example from Egypt." *International Journal of Water Resources Development*. 15.4 (1999): 543-560.

World Bank. *The Little Green Data Book 2007*. Washington, DC: World Bank, May 2007. Available online at: <http://siteresources.worldbank.org/INTEEI/

936214-1146251511077/21329572/LGDB2007.pdf> Last Accessed 14 August 2008.

World Bank. *Ethiopia: Irrigation and Drainage Project*. 21 June 2007. Available online at: <http://web.worldbank.org/external/projects/main?pagePK=64283627&piPK=73230&theSitePK=40941&menuPK=228424&Projectid=P092353> Last Accessed 10 August 2008.

World Bank. *Governance Matters 2008: Worldwide Governance Indicators, 1996-2007*. Washington, DC: World Bank, 2008. Available online at: <http://info.worldbank.org/governance/wgi/index.asp> Last Accessed 14 August 2008.

Zenebe, Wudineh. "Sugar, Ethanol Plant worth 300m Br for Amhara". *Addis Fortune*. 10 August 2008.