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Water and Power: The Rule of Law Struggle for the Most Basic of Needs

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Abstract

Redefining the traditional notion of the Rule of law, this paper establishes a strong connection between a weak rule of law and the prevalence of water, sanitation, and governance issues that plague slums across the globe. Using the Kasube Village in the Bwaise Slum of Kampala, Uganda as a case study, five specific problem areas are identified: the tragedy of the commons, monopolies, no means of succession, lack of understanding of issues/rights, and overall lack of accountability. The solution to these problems is to foster the newly defined rule of law in these informal communities. In order to develop the rule of law in slum communities, a seven-step procedure is presented as a generic model for NGOs and similar groups to follow during aid project management. This model is then applied to the five identified problem areas in the Kasube Village. While not the final solution to the issues of access to clean water and adequate sanitation, due to its focus on the rule of law, this model proves to be a better mechanism for sustainable progress than the methods currently being used.

"In developed countries, important information is relayed to the masses through the internet, television, newspaper, books, and schools. These are not options in the slums of the developing world."

Kasube Village Public Toilets

Introduction

In the Kasube village, 80 families share a row of six bathroom stalls. To classify these as bathrooms may be misleading. They are, in fact, holes in concrete slabs separated by thin pieces of plywood. These are the "private" toilets. Down the slope Kasube occupies, there are five public stalls. One of the stalls is completely open with no hole in the concrete and two others have been boarded off with a wooden slab precariously balanced on a rusted piece of metal. The remaining stalls have holes big enough for a child to fall into and are covered in wrappers, toilet paper, and debris. Farther down the slope, approaching the valley, there are no toilets in sight; unless one counted the ditches filled with grey water and trash lining the narrow dirt roads. Adjacent to the private stalls are three water spigots. Constructed by a NGO sometime ago, they have been non-operational for a while now. The prospect of their repair, by either the NGO or community, is bleak. There is a 10,000 liter water tank near the broken spigots. This is the primary water source for 80 families. It is the only water tank in the entire village. The rest of the villagers either have to buy water, which can be exorbitantly priced compared to the cost of water in the city, or retrieve water from natural sources. To clarify, the natural sources are rainfall, puddles from pipe leaks, or the same ditches that may have earlier served as their toilets.

This is the state of water access and sanitation in the village of Kasube. And it is a similar situation in the other 131 villages that comprise the Bwaise Slum in Kampala, Uganda. WaterAid maintains an informational page concerning water and sanitation in Uganda. It relays that 8,800,000 people in Uganda currently do not have access to safe water. Furthermore, over 22,000,000 citizens, almost two-thirds of the population, do not have access to adequate sanitation. And over 12,000 children die every year from diarrhea caused by unsafe water and poor sanitation.[1] It is not as though efforts are not being made to assuage these problems. Many volunteer projects have found a home in Kampala, from big name organizations like the Global Volunteer Network and World Bank, to grass root ones such as The Uganda Village Project and Project Uganda. But sustained success from projects similar to these has been rare.[2][3][4]

People know that the basic necessities of human life are currently not being met in slums of developing countries. Despite this

[1] WaterAid America Inc. *Home page*. Retrieved November 23, 2013, from http://www.wateraid.org/us/where-we-work/page/uganda

[2] The Sierra Leone Ministry of Water Resources reported the results of a map exercise conducted in 2012 of damage to public water points constructed in 2007. Of these, 31% were impaired (party or fully broken) and 17% broken down. Among the points constructed just one year prior in 2011, 22% were already impaired and 9% broken.
Hirn, Maximilian. *Sierra Leone Waterpoint Report*. Ministry of Energy and Water Resources, 7 (2012).

[3] During the Triple-S research seminar in Kampala, the International Reference Center for Community Water Supply (IRC) presented information about three districts surveyed in Ghana. They found that from 2010-2011, 45% of water point sources were partially functional, 7% non-functional, and 10% completely broken down.
Atengdem, Jeremiah. *Presentation- Assessing and monitoring water services in Ghana: findings for the Ghana baseline*. IRC (2012).

[4] Listening to Dar, a project designed to test whether mobile phone surveys can be used to rapidly and inexpensively collect data concerning public services, found that one in four toilets was not functional in Dar es Salaam.
Listening to Dar es Salaam. *Report 15: Water*. (2012).

knowledge and despite environmental engineering and social science projects, the conditions in these areas are not changing. Therefore, it seems as though a vital piece of the puzzle is missing from these efforts. That absent aspect is the rule of law.

This paper aims to demonstrate the close link between the rule of law and water and sanitation issues through five specific problems plaguing the Bwaise Slum. Then, briefly propose a generic methodology of fostering the rule of law in slums. And lastly, apply this technique to the specific issues in Bwaise in order to determine whether or not it is an effective proposition.

Definitions: Rule of Law

Before moving forward, it would be beneficial to qualify what is intended by the term "rule of law." There is the Rule of Law concept taught in law schools and the rule of law, which is a construct of the author of this paper, the latter, is more of an ideal societies strive to achieve.[5]

It is of crucial importance to know that rule of law may hold distinct appearances in various areas. Contrarily, if one were to assume the Rule of Law stance, it suggests that there is one Rule of Law standard. There are no variations and if a region did not exhibit all of the sanctioned traits, the Rule of Law would not exist there. This is a very hard benchmark for the United States, let alone a slum like Kifumbra which is currently attending to the issue of having only one toilet for every 4,000 inhabitants.[6] It is an even more difficult standard to meet considering the aspects of the Rule of Law are still debated amongst leading scholars.

The US Army doctrinal definition states that: "Rule of Law is a principle of governance in which all persons, institutions and entities, public and private, including the state itself, are accountable to laws that are publicly promulgates, equally enforced, and independently adjudicated, and which are consistent with international human rights principles."[7]

Andrew Altman, a distinguished professor whose book is used to teach legal principles at the Military Academy, asserts there are five basic principles to the Rule of Law. They are: the government must operate under the law, the government should maintain order and peace through rules, these rules should give individuals fair warning,[8] all persons must be given due process, and the people ought to establish constitutional government and then abide by its laws.[9]

The United Nations posits that: "[The Rule of Law] refers to a principle of governance in which all persons, institutions and entities, public and private, including the

[5] The American Bar Association. *What is the Rule of Law?* ABA Division for Public Education, 4 (2014).
[6] WaterAid America Inc, *supra*.

[7] This definition is based, in part, on the definition provided in the *Report of the Secretary-General: The Rule of Law and Transitional Justice in Conflict And Post-Conflict Societies*, U.N. Doc. S/2004/616, 4 (2004). US Department of the Army. *Field Manual 3-07, Stability Operations.* 1-9 (2008).
[8] Altman cites Lon Fuller's "The Morality of Law" (1964) as the basis for the conditions of "fair warning." These conditions include: 1) be made public; 2) be reasonably clear in meaning and specific as to what they prohibit; 3) be in force for a reasonable period of time; 4) be applied prospectively, not retroactively; 5) applied in an impartial manner consistent with their meaning; 6) be possible to comply with; and 7) are enacted in accordance with preexisting legal rules.
[9] Andrew Altman. *Arguing about Law: And Introduction to Legal Philosophy, 2nd Edition*. Wadsworth: Cengage Learning, 1-6 (2001).

State itself, are accountable to laws that are publicly promulgated, equally enforced and independently adjudicated, and which are consistent with international human rights norms and standards. It requires, as well, measures to ensure adherence to the principles of supremacy of law, equality before the law, accountability to the law, fairness in the application of the law, separation of powers, participation in decision-making, legal certainty, avoidance of arbitrariness and procedural and legal transparency."[10]

These definitions are not vastly different. They maintain ideals of accountability and equity under the law, but they are definitely not identical. And they do not independently or collectively establish an appropriate standard for which nations can be held. On the contrary, the rule of law approach is more malleable. It holds foundational the ideas from the multiple Rules of Law of promoting strong governance through appropriate regulations which both the people and government are accountable to. It advocates for a populace that is educated about laws and can maneuver comfortably within the legal system. It takes the essence of the various Rules of Law and finds characteristics that are specifically weak in these informal communities and tailors itself to addressing those flaws by making adjustments within the current legal structure. It is intended to be fostered on a much smaller scale; in this case, the slums of Kampala. The immediate outcome will not look like one of the definitional Rules of Law. And in the end, there will be no rule of law identity that can be assumed. However, each rule of law will manifest itself in the rectification of these respective communities' many crippling woes and provide an actually sustainable baseline of equity, accountability, means of succession, and regulation.

Slum

Alan Gilbert, in his article, "The Return of the Slum: Does Language Matter?" states that the United Nation's current method of identifying slums by absolute means is hugely problematic. He points out that slums are relative and the look, feel, accommodations, and typical dwellers vary from country to country.[11] Therefore, it would be helpful to consider the operational definition the UN-HABITAT has recommended: "[Slums] are areas that combine, to various extents: inadequate access to safe water, inadequate access to sanitation and other infrastructure, poor structural quality of housing, overcrowding, and insecure residential status."[12]

They are not consistently located on the outskirts of town or the centers of cities. There is no specific type of governmental structure within the slums giving them some sort of "slum identity." While the location and exact threshold of living on the margin varies with each region, it is important to note that all slums have basic needs that are not currently being met.

The Link

The link between the rule of law and water and sanitation accessibility/quality may

[10] The United Nations. *Rule of Law Home page*. Retrieved January 25, 2014, from http://www.un.org/en/ruleoflaw/

[11] Alan Gilbert. "The Return of the Slum: Does Language Matter?" *International Journal of Urban and Regional Research*. 31(4), 697-713 (2007).

[12] UN-HABITAT. State of the world's cities 2010/2011 bridging the urban divide. London and Washington: Earthscan Publications Ltd. (2008).

not be intuitive, but they are inextricably so. Currently, rule of law in these slum areas are negligible at best. This is supported by statistical evidence gathered by the World Justice Project in 2010, which sought to quantitatively assess the extent to which countries adhere to the rule of law. Data was collected in nine dimensions: limited government powers, absence of corruption, order and security, fundamental rights, open government, regulatory enforcement, access to civil justice, effective criminal justice, and informal justice. Each country received a number between zero and one, one signifying highest adherence to the Rule of Law. The results for Uganda, which were based on questionnaires and population polls from Kampala, Wakiso, and Mukono, fell consistently between 0.33 and 0.48.[13] The only countries of the 66 involved to continually rate lower than Uganda were: Bolivia, Cambodia, Ethiopia, Iran, Kenya, Pakistan, and Venezuela; nations not famous for their dedication to the preservation of human rights.[14]

Consider the status of water and sanitation in two of the countries that scored on par or below that of Uganda: Kenya and Ethiopia. Located in Africa and similarly situated within the sub-Saharan region, all three states have one major city, their respective capitals, and a large slum population. In Kenya, 16,000,000 people, of a total population of 42,000,000, do not have access to safe drinking water. Over 29,000,000 people, do not have access to adequate sanitation. And more than 10,000 children die every year from diarrhea caused by unsafe water.[15] In Ethiopia, over half of the population, 43,400,000 people, do not have access to safe water. Nearly four-fifths of the populace does not have access to adequate sanitation. And over 33,000 children die each year from diarrhea caused by polluted drinking water.[16]

In addition to those in Uganda, Ethiopia, and Kenya, WaterAid also sponsors major projects in Cambodia and Pakistan. Conversely, in countries that rated very high in the nine categories, such as Austria, Australia, Belgium, France, Japan, and Singapore, there are no WaterAid projects. In fact, these nations are sponsoring water and sanitation ventures in other countries.

There is clearly a strong link between inadequate rule of law and prevalence of water, sanitation, and governance issues. It would be hubris, however, to not also demonstrate a connection between a strong rule of law, or one in a higher maturation stage with a decline in those problems. Botswana is commonly referred to as a success story regarding the rule of law in Africa.[17][18] Over 87% of its

[13] The results from the WJP for Uganda had one outlier: In the category of "order and security," Uganda was rated 0.56. However, this category tended to have higher results across all participating nations.

[14] All of the methodology utilized by the WJP can be found in this document, to include the questionnaires that were given to the people.
Juan Botero and Alejandro Ponce. *Measuring the Rule of Law*. The World Justice Project- Working Paper Series, WPS No. 001, (2001).

[15] WaterAid United Kingdom. *Kenya Home page*. Retrieved November 27, 2013, from http://www.wateraid.org/uk/where-we-work/page/kenya

[16] WaterAid America Inc. *Ethiopia Home page.* Retrieved November 27, 2013, from http://www.wateraid.org/us/where-we-work/page/ethiopia

[17] Guy Hoffman, SC, Johannesburg Bar, in his article said: "[Botswana] has been transformed from a poor, largely rural, subsistence farming based country into one of the major success stories of Africa. Respect by government for the rule of law and the independence of

population has access to safe drinking water and in the last few years, the country has seen a rise of 10% in access to adequate sanitation.[19][20] In October of 2012, its High Court held that the customary law of land automatically being inherited by the oldest male in the family was unconstitutional. Edith Mmusi was able to counter the claim of her half-brother's son and keep the land of her recently passed father for her and her sisters in this landmark decision.[21] Also in 2012, when a female was denied the ability to take over the chiefdom of her tribe simply because she was a woman, she petitioned the High Courts. The High Courts found there could be no gender discrimination in who may succeed the throne.[22] These cases highlight the idea that with a strengthening of the rule of law comes a decrease of issues in accountability and governance.

Now that the connection between a struggling rule of law and the prevalence of water, sanitation, and governance issues has been established, this paper will focus specifically on problems afflicting the slums of Kampala.

Issue One: The Tragedy of the Commons

The Tragedy of the Commons is the theory that a common resource, bearing no singular owner, will be depleted by those that use it. This is because each individual will act in his/her own self-interest which is generally contrary to the good of the whole.[23] How does this relate to the situation in Kasube? The public stalls discussed in the introduction are the common resource and the slum dwellers are the individuals acting in their own self-interest. The villagers fill the stalls with garbage, to the point where they are unusable, because the alternative is that trash occupying space around or inside their homes. They do not incur the individual burden of consistently finding new ways to dispose of their garbage, rather they use a communal location that is available for at least the time being. This same attitude is taken in regards to the drainage ditches that border the dirt roads. Their convenient location makes them a usual target of trash disposal. The ditches fill up with garbage, water cannot pass through as necessary, and the result is sitting, polluted water; a perfect breeding ground for malaria and other diseases.

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the judiciary has played no small part of this success story."
Guy Hoffman. "The Rule of Law in Botswana." *Advocate,* (2003).

[18] Democracy Web, an online study guide developed by the Albert Shanker Institute and Freedom House, stated that "Transparency International (TI) has ranked Botswana the highest among African countries for the last several years, and ranked Botswana 38th out of 180 countries in its 2007 Corruption Perceptions Index (falling mainly behind the most established democracies in Europe and North America)." Democracy Web. Accountability and Transparency: Country Studies- Botswana. Retrieved February 24, 2014, from http://www.democracyweb.org/accountability/botswana.php.

[19] Central Statistics Office. Botswana Water Statistics. Gaborone: Department of Printing and Publishing Services, 9, (2009).

[20] Trading Economies. Improved Sanitation Facilities (%of Population with Access) in Botswana. Retrieved March 17, 2014, from http://www.tradingeconomics.com/botswana/improved-sanitation-facilities-percent-of-population-with-access-wb-data.html

[21] Wendy Zeldin and Constance Johnson. "Botswana: Landmark Case Ends Patriarchal Inheritance System." Library of Congress. Accessed via web. (2012).

[22] Freedom House. "Botswanan Court Decision a Victory for Women's Rights. Retrieved on March 16, 2014, from http://www.freedomhouse.org/article/botswanan-court-decision-victory-women-rights

[23] Nancy Kubasek and Gary Silverman. *Environmental Law, 8th edition*. New Jersey: Pearson, 118 (2011).

While this method of disposal may come across as lazy, it is important to understand the alternatives the community has for discarding waste. At this time, the community relies on one large garbage truck. It drives through the village and stops in a central location. Anyone with trash brings the waste to the truck and dumps it in the open back. The first problem this presents is that slum dwellers must have a personal receptacle for garbage. Some resourceful villagers make use of old potato sacks or several small plastic grocery bags. But some just do not have something as seemingly simple as a sack to store garbage in-between the trash collector's visits. The next problem is defining "centrally located." These are not small villages and the elevation of the Bwaise Slum is 1,200 meters.[24] This means some villagers must walk a significant distance, uphill, to even get to the garbage truck. And they have to carry their trash with them.

Issue Two: Monopolies

Nairobi's Kibera is the largest slum in Africa with a population of 2,500,000.[25] Because of its size, Kibera has adopted its own internal government to control water access, construction, and sanitation. But if one's tribe is not that of the internal government's, he/she could be denied access to clean water and forced to pay nearly three times more for water.[26] Because the Ugandan government does not provide any alternative means of access to water, a monopoly on water distribution is achieved. A monopoly is a "market situation where one producer controls supply of a good/service and the entry of new producers is prevented or highly restricted."[27]

In the Kasube village, the situation is slightly better, but still troublesome. At one point, there were spigots, which allowed people to come and fill up their yellow water jugs. The spigots are now in disuse and in their place is a 10,000 liter water tank. This tank is monitored by Mrs. Damamarie. She is the one and only gatekeeper. She is no slumlord. When news of an incoming project reached the village, Damamarie and thirty other villagers, began taking courses sponsored by Makerere University about gardening, management, and environmental engineering topics. Both men and women attended and she was the best performer. She was also close friends with the man who initiated the project and was made the project's manager. Damamarie is a seemingly fair and just woman, but she still must turn families away from the tank. It only has enough water for 80 families. Kasube village has much more than 80 families. Thus, like in Kibera, the problem of the "haves" versus the "have-nots" arises.

While Kasube does not have Kibera's recognizable internal government, there is clearly an informal hierarchy of leadership and they control the one available clean water source. For those families closest to the valleys, there is no clean water access. So they too are forced by the monopoly to seek other sources of water.

[24] WaterAid in Uganda. *Solid Waste Management: Study in Bwaise II Parish, Kawempe Division, Final Report* (2011).
[25] Kibera UK Charity. *Facts and Information about Kibera*. Retrieved on April 11, 2014, from http://www.kibera.org.uk/Facts.html
[26] Lwasa, *supra*.
[27] Business Dictionary. *"Monopoly."* Retrieved on April 10, 2014, from http://www.businessdictionary.com/definition/monopoly.html.

Issue Three: No Means of Succession

As the water tank project manager, custom within the village suggests Damamarie can hold her position indefinitely. This assessment is based on the careers of two other leaders within the slum: Sarah, the village secretary and Christopher, the village chairperson.

As General Secretary, Sarah spends her time writing letters of recommendations, introduction pages for passport applications, and job applications for the people of the village. She has held this position for seventeen years. She is one of the few villagers who can read and write, so when the time came for this position to be filled, Sarah was the unopposed victor. Christopher has been the chairperson for over twenty years. As chairperson, he determines which NGO sponsored projects are allowed in the village and how aid is dispersed. He is also the sole member of the slum that can voice the concerns of Kasube to the municipal government. The next "election" for chairperson will take place in 2016; twenty-two years into his time in office.

These are the three observable "key leader" positions in the Kasube village and for none of these jobs is there a mechanism in place stipulating what happens when the current occupant quits, retires, or dies. Why does this matter? Consider the ramifications of not always having a chairperson, secretary, or project manager in Kasube. If something happened to Christopher, while the community scrambles to find a worthy replacement, there is no one addressing the slum's concerns to the municipal government. There is no person to coordinate with NGOs or negotiate new projects. If this were to happen to Sarah, there would be a sudden halt in people getting passports or jobs. And if this happened to Damamarie, the regulated distribution of water would cease and anarchy would ensue as families attempt to obtain more than their fair share.

Issue Four: Lack of Understanding of Issue/Rights

Many people in the slum do not think there is a finite supply of water.[28] In Bwaise, flooding is massive and frequent, so understandably there is confusion about water availability. Worse than this common misconception, is that many Ugandans are wholly unaware of their water rights.

At the national level, water policy is strong and seemingly promotes the right thing-prioritizing clean water for domestic use. The Ugandan Constitution has helpful principles, one of which being that the state is obliged to manage water well. And then there is the Water Act and aspects of the Public Health Act which deal with specifics in environmental management.[29][30] But none of this has reached the local level, let alone the slum level. In fact, the professor of law in charge of the Regional Water Law and Policy Center at Makerere University says there are no laws at the local level that

[28] This information was gathered by the author from a personal interview conducted with Dr. Emmanuel Kasimbazi. Kasimbaze is a lecturer in the Department of Law at Makerere University. He specializes in environmental law and he will be in charge of the first ever Regional Water Law and Policy Center within the participating eight countries of the Intergovernmental Authority on Development (IGAD).
Dr. Emmanuel Kasimbaze. Personal communications with the author on March 18, 2014.

[29] Uganda Water Act § 152.001-107. (In effect since 1997.)

[30] Uganda Public Health Act § 281.70-89. (In effect since 1935.)

regulate water and sanitation.[31] And because the laws don't actually exist at this level, and the good national policies that do exist are unknown by the slums, the villagers operate under the assumption that it is simply not possible to regulate these issues.

Issue Five: Overall Lack of Accountability

As previously mentioned, the village chairperson has unabated autonomy to decide which NGO projects are allowed into the village and how to manage incoming aid. There are no checks and balances on his decisions and no one is privy to his methodology. The implication is not that Christopher is inherently corrupt, just that there is very little transparency in the current system. The chairperson also has the ability to take problems the community brings to him and refer them to organizations for help. But once the issue is passed up to Christopher, there is no assurance that anything will actually get done. The chairperson, like many American town council jobs, is an unpaid position. Christopher lives off the wages from his primary profession as a pest controller.[32] In order to maintain his livelihood, sometimes the needs of the people come second to the demands of his clients. But the people have no recourse to ensure the village chair is actually fulfilling his duties.

This lack of accountability is not just with the leadership. The people, as well, are not held accountable when they demonstrate complete disregard for the law. When it floods in Kasube, slum dwellers have been known to release the plugs in the pit latrines they are utilizing. This unplugging allows all of the pit latrines' contents, in other words, pure human waste, to literally ooze out of the latrine due to the water pressure and flow into the streets. When asked if people are held responsible in any way when this happens, Dr. Lwasa could only respond with, "Unfortunately, no."[33]

These five issues serve as major roadblocks to the longevity of clean water and adequate sanitation projects in the Bwaise Slum. Rather than reconfiguring the entire Uganda government, if one used the rule of law approach to address these specific issues, the slums could work to move *themselves* out of this critical situation in a sustainable manner.

The Rule of Law Approach

What does this rule of law approach look like? The following proposal is a step-by-step process of how a group can work within the current legal framework of a slum and foster the rule of law. These seven actions need to be taken prior to commencing any work within the slum. This procedure is put forth as a mechanism to be used in any slum, not just the ones in Kampala.

Use a multidisciplinary team/approach

Solutions to these problems require environmental engineering technology. Not even the strongest rule of law can conjure up the water tank necessary to physically disperse clean water. But these problems demand an accompanying legal solution. A borehole has a lifespan, laws do

[31] Kasimbaze, *supra*.
[32] This information was gathered by the author from an interview conducted with the chairperson of the Kasube village, Christopher.
Christopher (Unknown). Personal communications with the author on March 19, 2014.

[33] Lwasa, *supra*.

not. Rule of law needs to be fostered in the areas where environmental engineering projects are occurring because it is law that should dictate how the project is managed, used, and maintained. As was the case in Botswana, it is only through the law that sustaining change can be made.

These projects also need more than a savvy legal mind and a highly proficient engineer. An understanding of the slum's culture, their daily struggles, their past with foreign aid, and the ability to interact with individuals in a meaningful way requires the presence of a social scientist. Elisabeth Jean Wood, said that she wished she had an anthropologist with her when she was crafting her book Forging Democracy from Below. She spent two years in El Salvador talking to the populace about their relationship with the FLMN and observing their interactions. Looking back, she realized she missed some indicators. There were social cues a trained eye would have noticed that could have better explained the causal logic behind peasant support for the FLMN.[34]

In addition, there are historical implications that need to be considered when formulating this plan of action. When looking at regions in the developing world, the effects of colonization are very much alive and well. And their impacts on society, whether positive or negative, must be taken into account. A historical analysis would aid in the assessment of the past and present legal system that exists within the area in question as well as the attachment to certain customs.

This interdisciplinary approach to sustainability is not solely the brainchild of the author. In 2001, Cornell University added an interdisciplinary graduate minor to examine conservation and sustainable development to its curriculum. Their method focuses specifically on environmental, social, and economic goals.[35] The minor addresses the areas that would produce the greatest challenges to this approach differing interpretations of problems and specific disciplinary language amongst participating academic fields, but also notes "interdisciplinary approaches are often undervalued in academic work, but highly valued in applied work."[36][37] In essence, when people are actually addressing an issue, the convergence of many academic niches manifests itself and the realization that the issue spans more than just one discipline occurs.

The difference between the approach considered by Cornell and the one proposed in this paper is the inclusion of the legal field. While it is important to look at these problems from an environmental, social (to include historical), and economic standpoint, Cornell University has failed to see the relevance of a legal perspective. Formal or informal, there is a system of law and order that exists within every community. And it is through this organism that sustainable change will be implemented in the slums.

[34] Elisabeth Jean Wood is a Professor of Political Science at Yale University with a PhD from Stanford University. She spoke in the author's class on April 14, 2014. Her comments are included to provide substantive evidence behind the claim that social scientists are an essential part of this endeavor.

[35] John Schelhas and James Lassoie, "Learning Conservation and Sustainable Development: An Interdisciplinary Approach," *Journal of Nature, Resource, and Life Science Education*, 119, Vol. 30, (2001).

[36] Michael Redclift. Sustainable development: Exploring the contradictions. Methuen: London. (1987)

[37] Schelhas, *supra*.

There may be more academic niches that should be consulted when drafting a project team to handle water access and sanitation, but these specialty areas, at a minimum, need representation.

Operate via law and not via committee

In the interest of sustainability and community involvement, aid workers and environmental engineers have begun establishing village committees to take responsibility for managing water and sanitation projects. It is a lauded practice that allows villagers to promote the project within the community and be involved in the decision making process. But simply instructing the village to select a ten person committee to do all the tasks the aid organization instructs them to do is not a sustainable solution. These committees tend to fall prey to a myriad of problems. First, they are generally voluntary and provide no source of income. After time, committee members seek wage-earning employment and participate less on the committee. Second, a natural waning of interest over time, leads to staff turnover. Often times, as in the case of Kasube's chairperson, there is no mechanism in place for succession. Either the transition does not occur, or it happens, but does not maintain any of the momentum previously gained. Third, there is fear or jealousy within the community that those entrusted with this power on the committee are corrupt and abuse the system[38] and the list goes on. Managing a project via a committee does not generally coincide leadership that currently exists within slums. In the case of Kasube, there are individual leaders. Damamarie, Christopher, and Sarah all hold a great amount of power in the community. But they do not collectively form a committee, nor do they govern their respective aspects of community life with the help of a committee.

So use the existing structure in conjunction with rule of law to foster dependability in the current decision makers and then create sustainability for the system. Consider the US Constitution. Article 1 defines the roles and responsibilities for the legislative, and Articles 2 and 3 do the same for the executive and judicial. This gives the American people a list of expectations they may hold for Congress, the President, and the court systems. Additionally, it serves as a reminder to those parties of what they can and cannot do while holding these positions. Use this same idea, but on a much smaller scale and without needing forty signatures for approval. Define the roles and responsibilities of individuals already in positions of power and discover whether or not that position can assist in the development of the project. Now, there are many options the community can choose from such as expanding one of the currently existing jobs to include an added duty or creating an additional job to assume these duties.

Express these roles to the community; the whole community. This is more than a job description, it is the law. The law, and this position, exists with or without its current occupant.

Ask first

Solicit the villagers and discover what aspect of their community they believe needs changing. During the occupation of

[38] Breslin, Edward. *10 Years from Now- Rethinking Water Supply Management in the Developing World.* Johns Hopkins University Global Water Program (2010).

Afghanistan, this did not happen and major problems occurred. The infant mortality rate in Afghanistan is the world's highest.

Cadets listening to residents of the Kasube Village

For every 1,000 babies born, 122 of them die before the age of one.[39] It would be logical to want to donate to the construction of a good hospital to help lower these numbers because, clearly, based on these statistics, the biggest problem facing Afghans is improper child healthcare. But when Afghans were asked to identify what THEY believed the biggest three problems facing Afghanistan were, 28% said insecurity (attacks, terrorism, etc), 27% said unemployment, and 25% said corruption.[40] But USAID spent $60,000,000 on healthcare facilities. They were built in 2009, and presently, not one is open. A hospital that had the potential to hold 100 beds was started, but never completed.[41]

No one asked the Afghans what they wanted; what they felt could make the difference between living on the margin and living comfortably. The hospital project began in 2009 and the survey was conducted in 2012. Perhaps if those years were switched, a project could have been initiated that the Afghans were invested in seeing through to successful completion.

Engage the whole community

In developed countries, important information is relayed to the masses through the internet, television, news-paper, books, and schools. These are not options in the slums of the developing world. If laws are transcribed into a print medium, there is no guarantee that even if everyone has access to copies, they will be able to read and comprehend them. And television and internet use is not as widespread. A key aspect of the rule of law is that everyone understands the laws and regulations.

Everyone is made aware of their existence and then they are expected to adhere to them. In the context of the slums, attempts could be made to simply use word of mouth to relay important information to the masses.

Students of the Kasube Village School

[39] UNICEF. *Afghanistan Statistics page*. (2013). Retrieved on April 10, 2014, from http://www.unicef.org/infobycountry/afghanistan_statistics.html.

[40] Mohammad Osman Tariq and Fazel Rabi Haqbeen, et al. *"Afghanistan in 2012: A Survey of the Afghan People."* The Asia Foundation, 5 (2012).

[41] Jessica Donati and Mirwais Harooni. *"Ambitious US Hospital Project in Afghanistan faces Failures."* Kabul: Reuters (2014).

Or, like many NGOs, one could just engage the heads of clans or the superior social strata and expect them to pass the message along to the villagers through what is known as "community engagement" or the "process of working collaboratively with and through groups of people affiliated by geographic proximity, special interest, or similar situations to address issues affecting the well-being of those people."[42][43] In this scenario, however, it is still unclear whether everyone got the message or not.

To avoid these problems, engage the community as a whole. Use interpreters and multiple sessions if necessary and encourage village leadership to employ the same method. Give mass speeches to the largest audience possible instead of a chosen few.

Educate the villagers on what they really do not know

Many scholars believe that the issue is that in these developing countries, people simply do not understand what proper hygiene entails. UNICEF, Safe Africa, and Action Against Hunger are a few of the organizations that think the key to solving sanitation and hygiene problems in slums is to teach people the importance of washing their hands and utensils for cooking.[44][45][46] But Moses, our Bwaise slum guide and initiator of many projects in Kasube, confirmed that villagers understand they should be rinsing with soap and using clean water when preparing food; there is just not enough water to make this a realistic option.[47] It is a struggle to find even enough dirty water for their family to drink, there is rarely any left over to partake in other water consuming activities.

So instead, education should focus on what the individual rights are of the members of the community. It would be beneficial to explain the construct of the legal system in the state. Then, they should be taught what the national and constitutional laws are. This will at least create a base line understanding. It will be important to discuss law itself and its purpose. Aristotle explained it best when saying: "Law, however, has the power that compels; and law is reason that proceeds from a sort of prudence and understanding."[48] And it is equally vital to explain why law is the only way to give them sustainable solutions. This education will at a minimum, empower the villagers by simply creating a shared understanding. It will show that the law makes no exceptions based on your social standing which will provide encouragement to those that live adjacent

[42] Michael Hatcher. *Community Engagement: Definitions and Organizing Concepts from the Literature*. The Center for Disease Control. Retrieved on April 25, 2014 from http://www.cdc.gov/phppo/pce/part1.htm.
[43] Hatcher, *supra*.
[44] Safe Africa, Home Page, Accessed on 12 February 2014, from http://safeafrica.org/teaching-hygiene/.
[45] Annemarieke Moojiman. Water, Sanitation and Hygiene (WASH) in Schools, UNICEF, July 2012.
[46] Action Against Hunger, Home page, Accessed on 12 February 2014, from http://www.actionagainsthunger.org/impact/water-sanitation-hygiene.
[47] This information was gathered by the author from conversations conducted with guide, Moses, of the Bwaise Slum, while on a tour with the research group. Moses's actually job description is unclear, but it is apparent that he is well-respected within the slum and knows about every project being undertaken. Because the author was not privy to Moses' last name, all citations from Moses from this point forward will begin with "Moses, …"
Moses (Unknown). Personal communications with the author on March 19, 2014.
[48] Aristotle. *Nichomachean Ethics*. trans. 2nd edition. Indianapolis: Hackett Publishing Co., 15-16 (1999).

to the valley who have been excluded from participation for so long.

Aid in the establishment of slum regulation

After a strong relationship has been established with the members of the community through continued interaction, use that bond of trust to teach that regulation is the essential key to ensuring the law is embedded with their community. Now that they have an understanding and hopefully, appreciation, for the law they will know things can get better. But the community has to be willing to abide by the regulations set forth by the village chairperson. Once the community has been primed to expect and adhere to regulations, discuss different types of regulation with the leadership. Engage them on what has been most effective and what has been not so effective. Simply teach the village leadership and serve as a ready and willing resource for their questions. But allow the regulations to be borne from them. The leadership will at least be more inclined to adhere to laws that they themselves enact.

Most importantly, ensure enforcement mechanisms are in place

"A law without enforcement has little meaning."[49] In other words, regulation without enforcement might as well be no regulation at all. Legislation does exist at the higher levels, but because there is absolutely no follow through on the lower levels, it is as if the laws do not exist within the slums. This being the case, it is important to establish an enforcement mechanism in conjunction with any regulation. Enforcement is the only way to be sure that villagers actually follow the regulations. If the community knows that there is no way to figure out whether or not they have acted in accordance with the regulation, the regulation itself loses its own clout.

Enforcement mechanisms need not mean hiring a police force to spy on the townspeople and report their misgivings. It simply means some of the village leadership walking around the village every once in awhile to check on things; just as a commander in the Army will check on the quality of training sessions within his unit every so often. People in the village can also be hired for small stipends to monitor heavily polluted sites at their most frequented times, such as the public stalls at night. And lastly, when an individual is caught, he/she is punished. The slum in question would have to establish what the penalties are for certain "crimes" and ensure that no matter what one's social card is, he/she is disciplined equitably under the rule of law.

Using these seven steps, this paper posits that the rule of law can not only be nurtured in these slum areas, but it can flourish. This paper will now take these seven steps and apply them to the specific issues found in the slums of Kampala.

Background

Beginning with the first step, information particular to the Bwaise Slum must be gathered by an interdisciplinary unit. The most crucial takeaways from this interdisciplinary study are: an accurate account of the history of the region, an evaluation of the current social structure, and an assessment of the present state of

[49] Debra Post. In her speech opposing the New Jersey Highlands Act. Published in the *Morris Daily Record*, (2009).

the informal and formal legal system that the slum adheres to.

History

Before 1900, within the present borders of Uganda, the kingdom of Buganda was born. It was comprised of a sundry of clans as it became a land for refugees from surrounding kingdoms. There was one ruling king, but he would have sons with a woman from each tribe. A group of elders then determined which of the sons would succeed the king. This enabled the Buganda to never fall under the rule of one clan for long. Because of this advanced system, Buganda was able to expand its territory considerably. With each land acquisition, the king nominated a chief to manage its operations.[50]

The early 1900s marked the transition into the colonial era. The Bugandan chiefs lost half their land to the British as "Crown Land," but negotiated to maintain autonomy over the remaining half. Due to their advanced managerial skills, as the British began acquiring territory, they looked to the Bugandans to administratively rule the conquered lands. Their strategic location enabled them to grow cotton and the "hands-off" approach assumed by the British allowed the Bugandans to become rather prosperous. When the colonial government began establishing regulations restricting cash crops in the 1930s and 40s, the Bugandan people were not pleased and the push for independence began.[51] The Bugandan people, now just Ugandan, began to riot and burn down homes of pro-British chiefs. The country remained in chaos until Sir Andrew Cohen's arrival in 1952. He reorganized the Legislative Council to include representatives from all districts, a system that would serve as a prototype for parliament.[52]

In 1962, Uganda gained its independence from colonial British rule and the leaders began to factionalize. The man who came out on top was then- Prime Minister Obote. Under Obote's regime, the military assumed a very prominent role in Ugandan life and under this strict military reign Idi Amin Dada was promoted and considered a personal protégé. Soon, Obote found himself with a unanimous disavowal by his own party and the national parliament. Instead of resigning, Obote turned to his friend Amin to carry out a coup d'état to stay in power. His power play worked and he retained his position as ruler of Uganda. But as time passed, it was unclear whether Amin and the military would be able to be relied upon as loyal supporters.[53]

Amin eventually conducted a coup d'état to dismantle Obote's reign of terror. Under Amin, the size of the military doubled twice over and he spent his time in power promoting and manipulating the army. His resources were consumed trying to protect against a seizure of control by the ousted Obote. Despite all this, Tanzanian President Nyerere, with the Tanzanian Army and the Uganda National Liberation Army took Kampala in 1979.[54]

Uganda was never quite able to recover from this reign of atrocities. There was a brief period of democracy preceded by the

[50] Rita M. Byrnes, ed. *Uganda: A Country Study*. Washington: GPO for the Library of Congress, 1990. Section: Uganda before 1900.
[51] Rita M. Byrnes, ed. *Uganda: A Country Study*. Washington: GPO for the Library of Congress, 1990. Section: The Colonial Era.
[52] *Id*, Section: The Issue of Independence.
[53] *Id*, Section: Independence: The Early Years.
[54] *Id*, Section: Military Rule Under Amin.

first election in over eighteen years. But this change of pace was quickly changed back to the way things had been with the Second Obote Regime in 1981 to 1985 followed by more military rule under General Okello.[55]

Current Social Situation

Fast forward to Uganda today, located in East-Central Africa. Area-wise, it is slightly smaller than Oregon. According to a 2002 census, there are ten recognized ethnic groups, the largest of which is Baganda. The population is roughly 36,000,000 with almost one-half being fourteen years or younger. There are three prominent religions: Protestantism, Catholicism, and Islam.[56] There is one city and that is Kampala. Other seemingly urban areas are really just small towns, including Entebbe, which boasts the country's only international airport. The official language is English and Ugandans pride themselves in their ability to speak English; especially in the city.[57] Military expenditures are less than 1.5% of the country's total GDP.[58] However, nearly everyone in security, be it a police officer, mall cop, or hotel guard, carries an AK-47 at all times. And just recently, President Museveni signed into law a very divisive anti-homosexuality bill which is receiving quite a bit of international backlash.[59]

Uganda is about 80% rural. While there has been aid provided to the city and even the slums, the main priority of USAID are the rural areas. They currently have no projects in any of the slums of Kampala.[60] It is very evident that the situations in the slums are not at the forefront of everyone's minds. Even during discussions at Makerere University, there was more concern for water security on a regional level due to the anticipated effects of climate change and border security in light of the tumultuous situation in the neighboring Democratic Republic of Congo.

Present Legal Structure[61]

Unlike the previous two sections, this structure applies specifically to the slums and not to Uganda or Kampala. There are no courtrooms, informal or formal, in the slums. There is no Bwaise Slum police force. Everything that a person would need to lodge a complaint, seek legal assistance, or engage in litigation is on the municipal level. This keeps slum dwellers from partaking in the formal legal system for two major reasons. First, the time and resources it would take to travel into the city would prove difficult. Second, as

[55] *Id*, Sections: The Interim Period, The Second Obote Regime and The Return of Military Rule.
[56] CIA World Factbook. Uganda Home page. Retrieved on February 26, 2014, from https://www.cia.gov/library/publications/the-world-factbook/geos/ug.html.
[57] The author can attest to these specific social nuances from time spent in Kampala, Uganda. After speaking with many Ugandans spanning different ages and social classes, as well as simply observing people as they interact with one another, the significant British influence on the country and Uganda's appreciation for that British influence is very evident. Some examples include, Ugandans driving on the opposite side of the road and for breakfast, the menu always had an option of a side of baked beans, a uniquely British meal.
[58] CIA World Factbook, *supra*.
[59] Faith Krimi and Nick Thompson. *"Uganda's President Museveni signs controversial anti-gay bill into law."* CNN World. (2014). Accessed via Web.
[60] This information was gathered by the author from brief conversation with a member of the Health division of USAID in Uganda.
Michael Jameson. Personal communications with the author on March 19, 2014.
[61] All of the data in this section has been provided by Dr. Lwasa. As an urban geographer, he has spent a lot of time researching slum areas and he has the most accurate knowledge of how the system actually works. Lwasa, *supra*.

previously stated, the relationship between the municipal government and the villagers is troubled at best.

There is an underlying accepted social hierarchy that exists in Kasube and this is how order is upheld. The chairperson is the head of the system and persons with significant clout within the community take the places immediately under the chair-person. This hierarchy enables anyone with a higher recognized social standing to be able to punish those with lower standing. An example would be an interaction between Damamarie and a mother who lives closer to the valley edge and walks around barefoot. Clearly, Damamarie holds the superior social position. If Damamarie witnessed the woman throwing garbage into the public stall, according to the village's social construct, she would be within her rights to administer punishment.

There are no codified laws on how to run the community. And because the majority of those in the slum are squatters, they are not concerned with the actions of those "above" them. They are more focused on how to acquire food, shelter, and water for their families for the foreseeable future. As long as any actions taken by their social superiors do not directly impact their ability to continue living life, the slum dwellers are rather indifferent to the informal legal hierarchy.

While there is no exact threshold for the "right" amount of research conducted within a region, it can be presumed that professional judgment will enable one to know when moving forward is appropriate. For the sake of space, the assessments in the aforementioned three focus areas will conclude the author's first step, the interdisciplinary approach.

Application to Bwaise Slum

With step one of the process complete, step two is a permanent consideration throughout the duration of the project. Ensuring all measures are taken to conduct operations through formal or informal law and not via committees is essential to a project's longevity. The remaining five steps will now be applied in varying combinations to address the issues plag-uing Bwaise.

Solution One: Tragedy of the Commons

In the United States, the principal means of protecting the environment is direct regulation or the "setting of standards and mandating compliance through threat of fines for violations."[62] In other words, the government *dis-incentivizes* polluters. On the other hand, the US also *incentivizes* individual pollution control by offering subsidies. Subsidies, while not generally covering the entire cost of the measures taken to reduce pollution, exist "when the government pays, either directly by grants or indirectly by tax credit, to encourage pollution control."[63] Subsidies work best when a company/individual knows they will eventually be forced to clean up the pollution anyway, so it is more opportune to begin now while the government is contributing a small amount versus in the future when the government may not contribute at all.

So, on a much smaller scale, the village chairperson could enact regulations which either dis-incentivize the discarding of waste in communal areas, incentivize the use of the garbage truck, or do both simultaneously. In terms of a dis-incentive,

[62] Kubasek, et al, *supra* at 124.
[63] *Id*. at 122.

the chairperson could make it known throughout the village that anyone caught polluting will be punished. If someone is caught polluting the drainage ditches or public stalls, he/she will be legally compelled to clean up the affected area. This does not mean merely picking up the few scraps the individual just dumped, rather, cleaning the stall or ditch in its entirety. This option has the potential to be highly effective because 1) now there will be a person/people to clean up the effects of the tragedy of the commons, and 2) it is safe to say the desire to pick up someone else's dirty trash is disdained cross-culturally so, the populace may be less inclined to commit the crime.

The chairperson could either exclusively or in conjunction with the dis-incentive, offer an incentive. He/she does not have the luxury to provide tax relief or endow people with monetary compensation, so the chairperson will need to be more creative. As previously discussed, part of why villagers are unable or not motivated to take their refuse to the garbage truck is the requirement of having a carrying receptacle. In order to ease this burden, the chairperson could supply the slum dwellers with durable bags. A message would be distributed within the slum articulating that if people are seen using the garbage truck frequently, they will be rewarded by the village leadership for their efforts. This "reward's" lack of monetary value enables the community members to properly dispose of garbage for intrinsic reasons. But it lightens their load a bit. This idea may seem laughable- who would be provoked to care about sanitation and clean water because of bag? It is important to remember that many villagers understand what the right thing to do is, they are just unable to execute due to heavy costs of said behavior. Making this activity even slightly more manageable finally allows them to do this right thing.[64]

Solution Two: Monopolies

Governments regulate monopolies to protect consumers by trying to prevent excess costs. Without regulation, monopolies have the ability to increase prices unabatedly. While this is not the current case in the village, there is always a possibility of someone exploiting the system. Sans regulation, there is also no incentive to provide good quality service.[65] If Damamarie were to decide to simply shut off the water one day or to allow it to become rusty and unkempt, there is really nothing the villagers can do. In order to avoid this hazard to consumers, it is clear the slum needs to regulate its water. Some scholars argue that access to water is a fundamental human right and should not be treated like a commodity.[66] However, if water was treated like a commodity and regulated by the slum, it could lead to diverse market options, potential entrepreneurialism, and a stronger sense of ownership and accountability of the water sources.

Christopher or Moses, both of whom have connections enabling them to funnel projects into the village, could enlist the help of NGOs to establish two other water source points. The author acknowledges this is no small undertaking. That being said, one of these water distribution points could be a meter created by Shack/Slum

[64] Moses, *supra*.
[65] Tejvan Pettinger. *Regulation of Monopoly*. EconomicsHelp. Retrieved on April 16, 2014, from http://www.economicshelp.org/microessays/markets/regulation-monopoly/
[66] David McDonald and Greg Ruiters. The Age of Commodity: Water Privatization in Southern Africa. Sterling, VA: Routledge, 1-3 (2005).

Dwellers International (SDI). These meters are valves with access to a clean water point. They are equipped with low-technology card reading capabilities. Villagers put money on their cards and then use the cards in the meter.[67][68] There is no gate keeper. The system cannot discriminate. The next distribution point could be one of many different options, a spigot, a hose, or even a person who travels and sells clean water.

Now that a diverse market has been created, both the distributors and consumers are more invested in their respective distribution point's success. Because there are more source points, fewer families have to use the same one and the less people who use the product, the more ownership is felt by those who do. In line with this logic, if a part failed or needed replacing, those users would be more inclined to collectively act to fix the issue. Here is where regulation comes in. The village leadership can establish nonnegotiable price caps for water sales. Using the price required by the water meter, the chairperson will disallow any water distribution that is more costly to the villagers in order to avoid any exploitation. Now a regulated competitive market has been established which could lead companies to begin finding more cost effective means of acquiring and distributing clean water. And since there are no barriers for entry into the market, and the price cap is expressly known by the community, there is potential for villagers to engage in this business and become entrepreneurs.

[67] Lwasa, *supra*.
[68] Shack/Slum Dwellers International. Home page. Retrieved on April 16, 2014, from http://www.sdinet.org/.

Solution Three: No Means of Succession

There is a known line of succession if the President were to die or leave office. In fact, because of Article II, Section I of the Constitution and the Presidential Succession Act of 1947, the exact order of who will take over the presidency is known.[69] And while, chairperson of the Kasube village is not on the same scale as a presidency, having a plan for the slum to run beyond one man's tenure is still important. In terms of Kasube, the village leadership has at least two rule of law options. Alternative one is to create a list similar to that of the Succession Act. Amongst the well respected individuals of the village, construct a fitting and ordered list of viable replacements. After appropriately communicating the list to the community, it can be used if the chairperson seat becomes unexpectedly vacant. Alternative two is to simply create a transition plan that includes how to proceed with currently existing positions / projects. There could be an apprenticeship program for youth to learn the tools of the trade and expectations of the position, thus avoiding each consecutive leader having to learn the job from scratch. This would guarantee that someone has the necessary skill set to fill in the position if the need arises.

Either option could lead to the community exercising greater care in the selection of certain positions that may lead to eventual chairperson-ship or election or being more cognizant of young slum dwellers with budding leadership talent.

Solution Four: Lack of Understanding of Issue/Rights

[69] 3 U.S.C. § 19

In the movie, "The Man Who Shot Liberty Valance" the main character, a lawyer named Ransom Stoddard, managed to take a hopeless, lawless Old Western town being terrorized by a bandit and his cronies and infuse it with the rule of law. The town sheriff was an ineffectual buffoon and much like the Kasube village, the towns-people did not believe there were any laws that could protect them from Liberty Valance. Mr. Stoddard opens a law practice, begins teaching law classes, and even helps establish an election process for the territory's delegate. He empowers the townspeople with the rule of law, and they develop into a thriving society.[70] While perhaps an Old Western film is not the most academic of comparisons, the movie provides an excellent analogy to the slums. The lawlessness plaguing the town of Shinbone is the same lawlessness that plagues Kasube. The people do not know what they do not have- the rule of law and they feel as though there are no solutions to their problems. But once they are educated on the subject matter, just like the people in the old western, they will have the tools necessary to transition from a society where the person most capable of inflicting serious damage retains the power to a society where the people hold the power. Rule of law establishes equity protected by the law that has previously been missing from these slums.

Classes, similar to those in the movie and to those which have been held by the University in the past, should be held. In these classes, law should be the topic. The Ugandan Constitution, the previously discussed environmental laws, criminal law, corresponding punishments, the meaning of the law, its purpose, and its role in sustainability should be taught. People need to be informed and they have no other means of acquiring the information themselves. A more knowledgeable pop-ulace is what is necessary for the rule of law to truly take hold so educating the slum dwellers must be a part of the solution.

Solution Five: Lack of Accountability on Both Ends

The community needs to see the authority of the chairperson regulated. Instead of having complete freedom to make major decisions, the chairperson could have to consult the secretary and project manager prior to allowing or disallowing a project into the village. A mandated democratic voting process amongst the leaders of the village is a Western concept that is not well suited for the village at this time, but this conversation may beget enlightenment and differing perspectives on a particular topic that contributes to the effectiveness of the final decision. Additionally, the chair-person could be required to publicly speak on the rationale behind decisions he makes concerning the village as a whole. This "talk" would not usurp the authority of the chairperson. It would simply shed light on the decision making process and serve as a "check" to ensure that actions are fair because they will have to be announced to the community.

On the other hand, the community members must also be held accountable for their actions. Through a combination of leadership checks, where Christopher, Damamarie, and Sarah simply walk around the village to assess different problem zones and address them on the spot, and potentially a small force of adolescents are

[70] David W. Livingstone. "Spiritedness, Reason, and the Founding of Law and Order: John Ford's The Man Who Shot Liberty Valance." Vancouver: Heldref Publishing, 217 (2009).

tasked to monitor certain common areas, the message will be sent that the laws in place are not idle threats or jokes. These laws are to be adhered to or consequences will follow. These consequences will not be arbitrary or capricious, but fair and public knowledge. People will know that their actions bear certain, inalienable punishments.

Conclusion

Ultimately, this solution may not be the final summit of the mountainous problem that is the lack of clean water and poor sanitation inside slums, but it definitely represents significant strides closer to the peak from where aid projects in Africa currently are. The admission of this paper not being the perfect answer to the water and sanitation issue is not a failure of the rule of law, rather a beautiful exemplification of it. This methodology and specifically proposed changes within the Kampala slums will most certainly create a stronger, more aware community. However, circumstances change. And the law is expected to address those changes and provide elucidation and stability for people. This augmentation of the rule of law in slums across the globe will enable villages to have the tools and experience necessary to react to an evolving world. As a community's ability to mitigate the issues of water and sanitation within its borders increases, but then those mitigating factors are complicated by climate change, rises in global interaction, and increases in population size, they will not be left completely helpless. The less rigid, more adaptable introduction of the rule of law into their daily lives will arguably render them better prepared to make adjustments in their legal system than regions which have taken a more unyielding approach.

A child collecting water from a drainage ditch in the Kasube Village.

"The solution to these problems is to foster the newly defined rule of law in these informal communities. In order to develop the rule of law in slum communities, a seven-step procedure is presented as a generic model for NGOs and similar groups to follow during aid project management."

Changes in Human Vulnerability and Resilience with Respect to Various Streamflow Allocation in the Nile River Basin[1]

By Jesse Horne, Margaret Crisman, Spencer Carroll
Advisor: Dr. Bruce Keith, Department of Systems Engineering

Abstract

The purpose of our study is to develop a model to understand how changes in water availability can affect changes in human dynamics relating to vulnerability and resilience within Egypt over a specific time horizon. Our team collected data from various resources specializing in indices used to measure and monitor human dynamics. These data served as inputs into our systems dynamics model. Output of our model provides us with a holistic understanding of Egypt's level of vulnerability and resilience based on our determined dashboard of indicators. Analysis of these indicators under certain plausible scenarios, has enabled us to provide evidence concerning the potential timing of a national collapse. Over a 25 year time horizon, we have found that Egypt is in danger of such a collapse if it is unable to improve its agricultural system.

"Population directly influences water capacity, which subsequently affects agricultural production with respect to nutrition, thereby impacting Egypt's future growth rate."

The Nile, Uganda

[1] Funding for this project was provided by the Coastal and Hydraulic Lab at ERDC, Vicksburg, MS.

Introduction

The Nile River Basin is a source of concern for both regional and national conflict, due primarily to its water limitations and projected population growth, Egypt has taken an aggressive international stance in relation to water rights due to their high dependency on Nile River stream flow. The 1959 Nile Waters Agreement split water rights of the Nile between Egypt and Sudan (Eckstein 2014), thereby excluding the remaining eight countries from accessing the Nile. Egypt currently appears to consume most, if not all, of the Nile flowing into the country. Consequently, the viability of Egypt's human systems, particularly agriculture, appears to be potentially vulnerable. As the water resources that are required to manage these systems declines,

the potential for regional conflict over water becomes a possibility. These human systems affect the interaction of human activity with water resources involving the sector of agriculture. How humans react to the variability in stream flow plays a significant role in determining the outcome international politics within the Nile River Basin.

The purpose of our study is to develop a model to understand how changes in water availability can affect changes in human dynamics relating to vulnerability and resiliency within Egypt over a specified time horizon. Insofar as changes in water availability, as it relates to Egypt's water consumption, could potentially undermine local and regional stability within Egypt, this paper is divided into four objectives, which relate to vulnerability and resilience within Egypt. The first objective is to appropriately define vulnerability and resilience with respect to how these issues affect human dynamics on the national level. The second objective is to apply this framework of national vulnerability and resilience to Egypt as a function of the stream flow of the Nile River. The third objective of our study is to apply our knowledge from the literature review into the development of a systems dynamics model that will give decision-makers an indicator of the Egypt's vulnerability and resilience. Several indicators will be modeled (population, nutrition, grain production etc.) as a function of stream flow from the Nile River. The fourth objective is to select those indicators from the model that are the most vital to Egypt's survival. These indicators will serve as a dashboard that our team will use in development of a Human Vulnerability Index. Overall, this model will help to inform commanders and decision makers on the potential thresholds of stream flow that may induce specific political and social changes within Egypt.

Vulnerability and Resiliency

In his book, *Collapse*, Jared Diamond (2005) provides evidence that social collapse is attributable to the dynamic interaction of a set of factors. These factors include resource capacity (deforestation, environmental degradation, soil fertility problems, water management problems), over-use of scarce resources (hunting, fishing), population growth, agricultural decline, pollution, climate change (temperature and precipitation), and war. The interactive combination of these factors set into motion outcomes on communities that undermine long-term sustainability of human populations. The result is collapse of human societies. The problem is one of creeping normalcy—changes occur regularly but too slowly for routine human detection—followed by a

rapid collapse when a population has overshot its carrying capacity. Diamond contends, as did Meadows, et al. (1972) and Forrester (1973), that the process of collapse is both detectable and manageable when consideration is directed toward system dynamics and sustainable management of resources.

Directing attention toward the sustainable management of resources requires one to regularly assess issues associated with vulnerability and resilience. Vulnerability is "related to the exposure and sensitivity of a system, i.e., the extent to which it may be impacted by a hazard, whereas resilience is more concerned with a system's ability to absorb and respond and adapt to disturbances and disasters" (Becker, Hoagland 2014, 5). Resilience can best be defined as the capacity of countries to function, so that the people living and working, particularly the poor and vulnerable, survive and thrive no matter what stresses or shocks they may encounter (The Rockefeller Foundation 2014, 2). Our study is concerned with both vulnerability and resilience in Egypt. We are analyzing multiple vulnerability and resilience indices in order to shape our own index that pertains to our topic of study. There are several indices that are relevant to the application of our study. It is important to understand how these indices and variables mentioned below are used in order to describe water scarcity issues across different regions in hopes to apply a handful of these variables to our own case study regarding water issues within Egypt.

The most well-known index for measuring vulnerability in terms of water scarcity is the Falkenmark indicator. This index has been established as the international standard for determining water stress on the national level (Brown 2011, 1). The two variables required to determine a country's vulnerability to water stress are total population and total annual runoff available. From this information, we can determine per capita usage (m^3 per capita). A value greater than 1,700 m^3 indicates that there is no national stress, while a value less than 1,000 m^3 indicates that there is a national issue concerning water scarcity.

Another relevant index is the Fragile States Index created by the Fund for Peace organization. This index, formally known as the Failed States Index, is based on twelve primary social, economic, and political indicators as well as over 80 different variables. All variables are ranked on a scale of one through ten based upon the severity of that specific category's pressures. Scores exceeding seven would equate to a high level of vulnerability, suggesting that a particular country was vulnerable with respect to a particular variable. As of 2014, Egypt scored a 7.1 for Demographic Pressures and 7.9 on the economic decline scale, placing it as a country on high alert (Fund For Peace 2014).

There are numerous other indices that draw a relationship between water scarcity and national vulnerability. Sandia National Laboratories developed a Human Resiliency Index (HRI) that "ranks countries according to their human and ecological condition and resilience to shocks associated with that condition" (Passell 2012, 7). "The HRI is postulated to be an indicator of an increase in the presence of conflict due to poor conditions for human resilience" (Passell 2012, E-1). The South Pacific Applied Geoscience Commission (SOPAC) and the United Nations Environmental Program developed an

Environmental Vulnerability index that analyzed the following categories: climate change, biodiversity, water, agriculture, human health, desertification, and exposure to natural disasters. Their index was designed for the purpose of "using this index with economic and social vulnerability indices to provide insights into the processes that can negatively influence the sustainable development of countries" (Kaly 2004, 1).

Applications to Egypt

Egypt appears to be extremely vulnerable to changing water conditions. From the aforementioned indices, we begin to narrow our scope to determine the variables most applicable to our case study. These variables, which include agriculture, arable land, water consumption, crop yield, grain production, population, gross domestic product, and nutrition, map out the dynamic interplay that describes the water scarcity issue currently occurring in the Nile River Basin. By understanding how these variables interact with one another, we can begin to determine key indicators that contribute to the various issues within Egypt.

Total water withdrawal in 2000 was estimated at 68.3 km^3, in comparison to Egypt's 84 km^3 (FAO Water Reports 2005)[2]. Egypt's current population is approximately 82.1 million people, showing that the country has used 80.9% of the total water available.

Agriculture is the largest consumer of water in Egypt. Total agricultural water consumption was 59 km^3 (FAO Water Reports 2005),[3] of which 83.1% comes from surface water and 10.1 % comes from groundwater (FAO Water Reports 2005). Agriculture provides livelihood for 55% of the population (El-Nahrawy 2011). Irrigation potential for agriculture is estimated at 4,420,00 hectares and the total area that is equipped for irrigation in Egypt is 3,422,178 hectares in 2002 (El-Nahrawy 2011). Furthermore, 85% of this area lies in the Nile Valley and Delta (El-Nahrawy 2011).

Of the land used for agriculture more than 90 percent of the land used comes from the Nile Basin (El-Nahrawy 2011). The allocation of stream flow is also a key factor in determining the amount of arable land. Only 3.68% of the land within Egypt is suitable for agricultural growth (Trading Economics 2011), which means that the vast majority of the land is arid desert. Approximately 90% of Egypt is desert, so fertile land is very scarce (El-Nahrawy 2011).

Egypt's farmers make up 29% of the agricultural labor force (CIA 2013). Farming communities depend of a constant stream flow in order to produce their crops. Farmers rely heavily on this steady stream flow in order to plan their crops and farming patterns each year. Due to the high density of population surrounding the Nile, the majority of arable land surrounds the Nile's banks. Egypt is a leading exporter of cotton, sugar, and wheat. Egypt has increased production and chosen to focus heavily in certain areas. These areas include: "cereals, fruit, sugar crops and vegetables areas. [They] have increased

[2] 1 km^3 is the same as 17,963,699,560,354 gallons of water

[3] The driest country in Africa is Egypt with 51 mm/year on average per year. This also leads to a 96.9% dependency ratio when it comes to renewable water resources. (FAO Water Reports 2005)

from 2.0, 0.17, 0.11, and 0.43 M ha in 1980 to 2.98, 1.43, 0.25, and 0.74 M ha respectively in 2008/2009" (USDA Foreign Agricultural Service 2014).

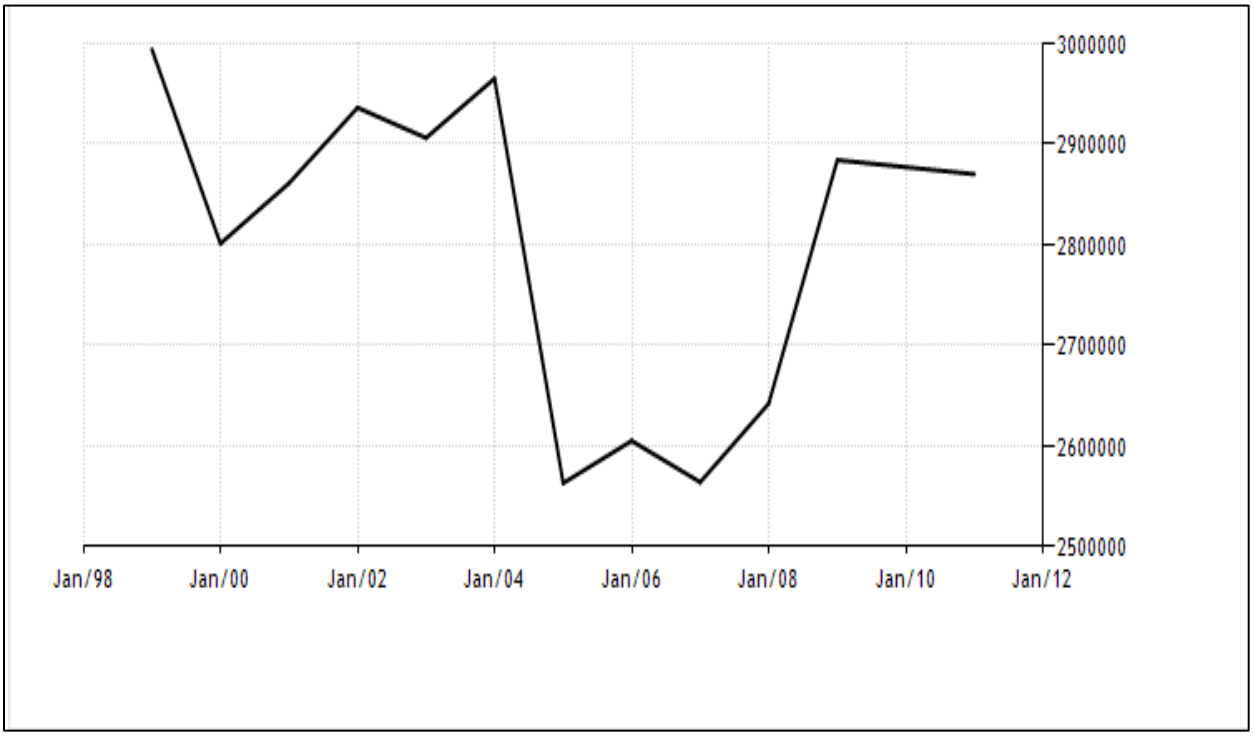

Figure 5: Arable Land

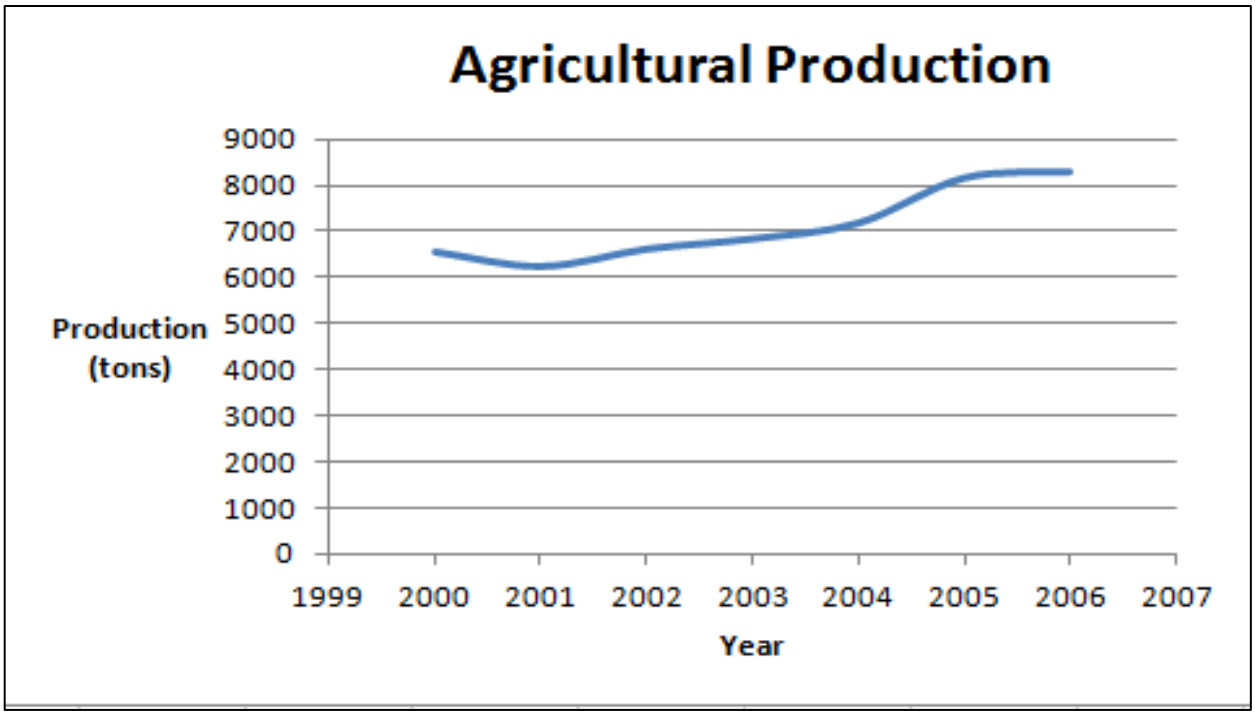

Figure 6: Agricultural Production

Subsequently, more water is needed from the Nile in order to keep up with this demand. Furthermore, oil and fodder crops, or crops that are used for purposes other than human consumption, areas have decreased from "0.48, 0.08, 1.28, and 0.14 M ha in 1980 to 0.22, 0.02, 1.17, and 0.13 M ha respectively in 2008/2009" (USDA Agricultural Service 2014). Crops are grown both in the Delta and in the Valley. However, the main exceptions being rice that is mainly grown in the Delta, and sugarcane which is grown in the Valley (FAO Water Reports 29 2005). The main winter crops are wheat, clover, and berseem.

The main summer crops are maize, rice, and cotton (El-Hahrawy 2011). The summer will obviously require more water because crops yields are biggest in the summer and that is when the majority of exported crops are grown.

Cereal grains are the primary main crops produced by Egyptian farmers. Of these, wheat is the most prominent. These food products are the biggest contributors to Egypt's level of nutrition (measured as calories per capita).

The population within Egypt currently exceeds 83 million people, the majority of whom reside along the Nile River. The population has increased by roughly 5 million people in the last four years, with a growth rate of 1.6% (FAO). With this rate of growth, Egypt can expect to have a population of nearly 97 million by the year 2025. The bulk of the population lives in

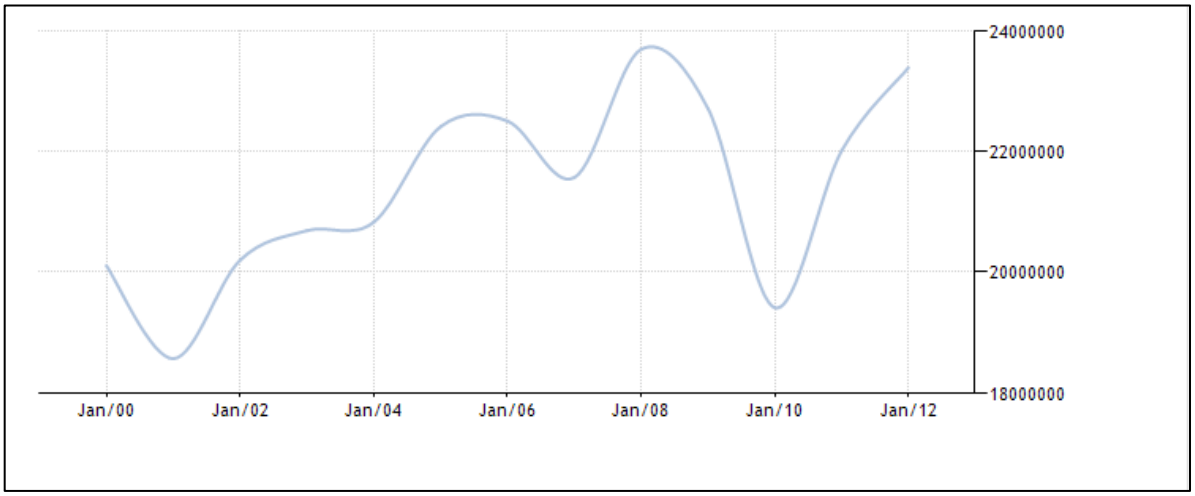

Figure 7: Egyptian Grain Production

Cairo and Alexandria, two of the major cities in the country. Both cities rely on a steady inflow of water in order to sustain day to day operations. There are roughly 3,800 people per square mile in these cities, compared to the 181 people per square mile when considering the country as a whole.

The gross domestic product (GDP) of a country essentially describes how large a country's economy is; essentially, the dollar value of all goods and/or services produced over a specific time horizon. The historic trend for Egypt's GDP suggests that it is increasing.

This increase may be attributed to both an increasing population as well as more

crops being produced for consumptions as well as exportation. In 2001, Egypt had a GDP of roughly 100 billion dollars. Over the course of 12 years, their GDP has grown to be more than 250 billion dollars. If GDP increases but stream flow does not, the economy will not be able to keep up with the growing state of Egypt.

Arguably one of the most important variables affecting Egypt's population is nutrition, measured as caloric intake per capita per year. Nutrition is directly related to the allocated stream flow into a region. If the stream flow of a region is not adequate to sustain sectors such as agriculture, the region will not have enough food to provide for the population. Historically, the caloric intake per year has fluctuated between 800,000 and 900,000 calories per person over the last twenty years. In 2010, there was a sharp decline in the amount of calories consumed despite the rise in almost all other economic categories. However, in the ensuing years, nutrition levels have increased.

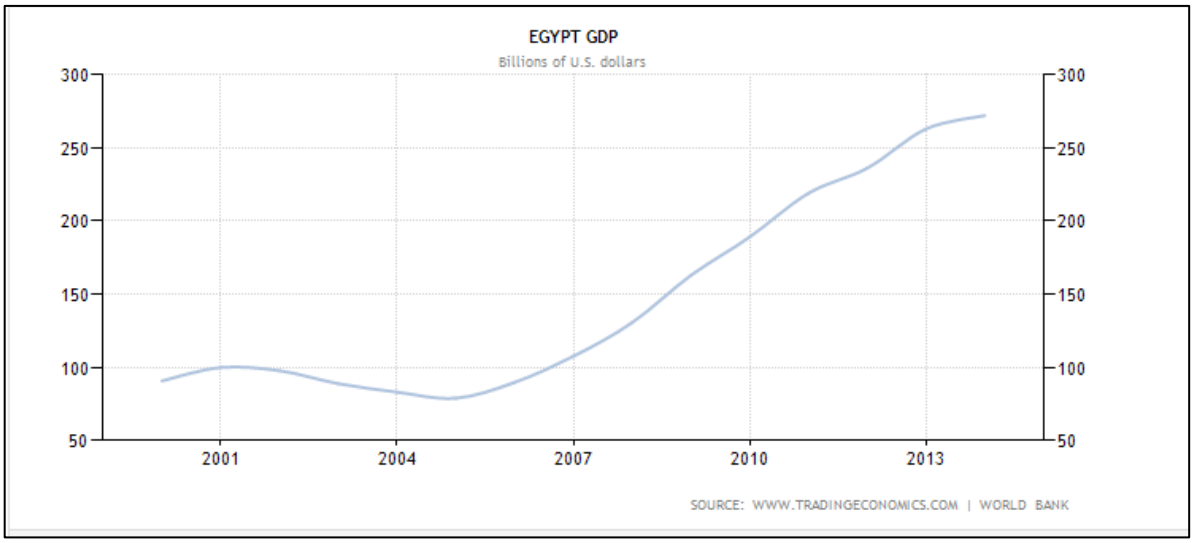

Figure 10: Egyptian GDP

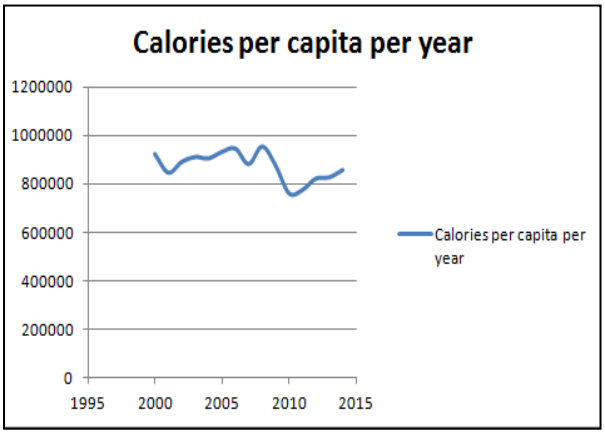

Figure 11: Egyptian Nutrition

Putting it All Together

Comparing the variables derived from our indices to the variables taken from our preliminary model, we have found that four main indicators drive this systems dynamic model: population, water consumption, agriculture, and nutrition. As stream flow into Egypt changes, allocation of this stream flow is likely to have a different amount in various intra-country sectors. Egyptian economy relies on a steady stream flow into these sectors, and the government will have no choice but to

intervene in order to preserve a specified stream flow threshold. As more water is being consumed coinciding with a growing population, the amount of agricultural production will decrease due to the lack of water available for agricultural purposes. If there is not enough agricultural production to support Egyptian population, the overall nutrition (caloric intake per year) for the population will similarly decline. If the population is not receiving adequate nutrition to support their health, it is likely that the Egyptian population will either decline or plateau. By modeling these key variables and how they relate to one another, the intra-national dynamics can be shown and manipulated in order to produce the most efficient method of water use.

Research Questions

Our model will enable us to answer several insightful questions regarding Egypt's level of vulnerability and resilience.

1. Which of the key indicators discussed above (population, nutrition, GDP, etc.) are most affected by variations in stream flow from the Nile River?

2. Where does Egypt score on the Human Vulnerability Index given certain plausible scenarios? And what scenario makes Egypt most vulnerable in the short term?

3. At what point does Egypt fall below our threshold values given a 25 year time horizon?

Model Development

Through research and analysis of the above indicators and variables, we have arrived at the following hypothesis, which will drive the construction of our model. Population directly influences water capacity, which subsequently affects agricultural production with respect to nutrition, thereby impacting Egypt's future growth rate. By protecting, monitoring, and improving the health of families and communities through the promotion of healthier lifestyles, the quality and accessibility of Nile stream flow becomes possible. Nutrition is the most important aspect of human vulnerability. Similarly, the domestic availability of water is a supporting indicator that accounts for the domestic usage of water by households and various communities. Finally, Egyptian jobs and the workforce that need water as a means to keep their businesses afloat also take up a significant amount of incoming stream flow.

These dynamic inter-relationships are captured in the following causal loop diagram. Determining how critical water is to human vulnerability is significant to our project scope in terms of vulnerability and resilience. Human vulnerability is a complex phenomenon that includes social, economic, health, and cultural factors. Vulnerability has two sides: susceptibility and the capacity to cope with or recover from the consequences (Building Human Resilience). The first side, susceptibility, can decrease through prevention and mitigation techniques that aim to preserve water. How prepared a population is, their response to changing stream flow conditions, and the recovery measures that are taken, all increase human resilience within a country (Building Human Resilience).

Methodology

The purpose of our study is to develop a model at the national level to understand

how changes in water availability can affect changes in human dynamics relating to vulnerability and resiliency within Egypt. The focal point of our model will be developing relationships between these secondary indicators and our primary indicator. Given quantitative values for these indicators, we will be able to create an index for human vulnerability within Egypt. This will give us detailed insight into Egypt's vulnerability and resiliency in response to changes in water availability. Our background research on water consumption in agriculture and energy production is critical in determining how Nile River stream flow relates to our pre-selected list of indicators.

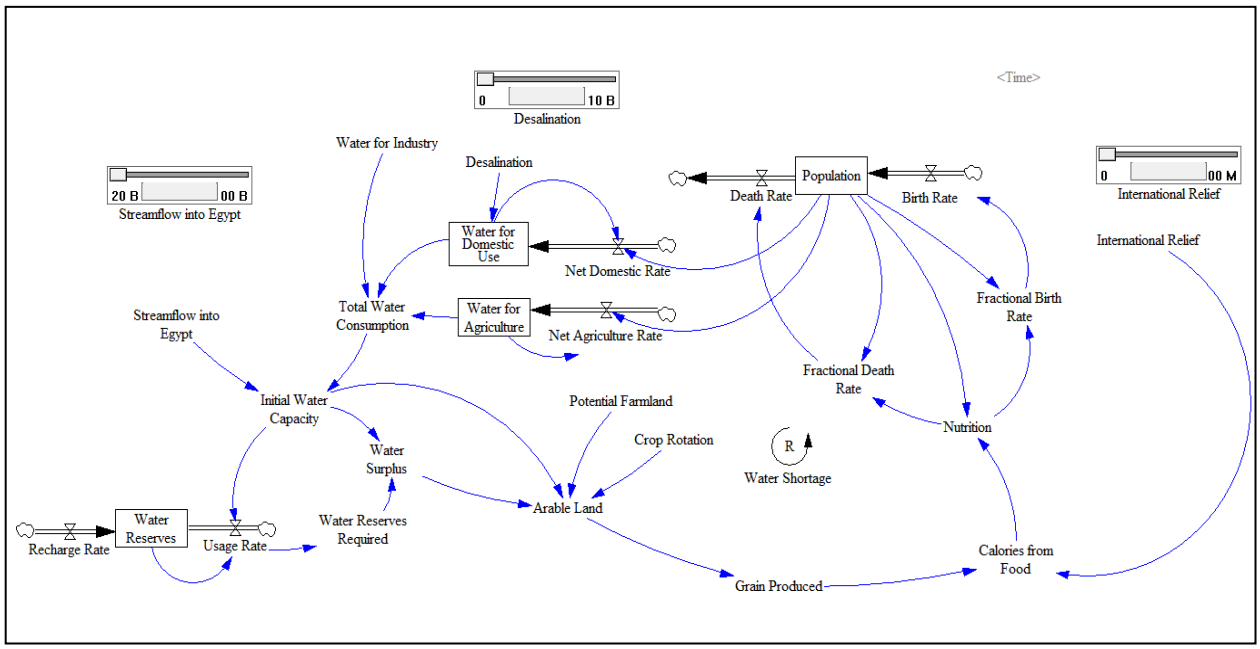

Figure 12: Human Dynamics Causal Loop Diagram

Data Sources

Data for our model is obtained from two primary sources: the Food and Agricultural Organization of the United Nations (FAO) and the international economic data from the Trading Economics organization. All other references used in determining the relationships within our model have been recorded in the Works Cited portion of this report.

Model Assumptions

The following assumptions are applicable:

- The model's sources of water consumption (agriculture, domestic use, and industry) do not include non-human, environmental factors such as evaporation. Factors involving Egypt's climate will make our model much too complex and go beyond the scope of our project.
- This model approaches Egypt as a closed, self-sufficient system. The only exceptions to this rule are the inputs of stream flow and international relief. Analysis of the global economy is outside the scope of this system dynamics model.
- We are assuming that 100 percent of Egypt's grain production goes into feeding the Egyptian population. In reality a marginal

percentage of grain is used to feed Egypt's livestock, which indirectly feeds the population. Quantifying this complex relationship is beyond the scope of our project.

- There are no technological improvements in the region, specifically relating to irrigation techniques (i.e., constant irrigation techniques).
- We will assume that Egypt does not import any food products from other countries and is self-sufficient agriculturally.
- We are assuming that the amount of potential arable land is a fixed constant. This is in direct disagreement with the current agricultural plan for Egypt (The Grand Plan), which states that diverting more of Egypt's water reserves toward irrigation will increase arable land.
- We are assuming that the stream flow into Egypt is not affected by increasing temperatures as a result of climate change.

Modeling Platform

Our model will be built from the Vensim software platform (Sterman 2000). Vensim is a visual modeling simulation program that allows for the conceptualization, analysis, and optimization of models of dynamic systems. It provides a simple yet powerful way to build simulation models from causal loop or stock and flow diagrams based on extant assumptions. This platform enables us to combine population growth models at the country level concurrent with river flow for the region in order to develop an integrated dynamic system model.

System Dynamic models provide a mechanism with which one can generate simulated scenarios (outcomes) from a connected set of feedback loops. Outcomes are produced through the mathematical integration of stocks (quantities) from inflows (quantity that flows into the stock over time) and outflows (quantities that flow out of the stock over time).

Our model will seek to answer our research questions presented in the previous sections. Our key variables in the model will combine to form a dashboard of indicators. These values will enable us to quantify Egypt's current vulnerability and resilience using our Human Vulnerability Index. In addition, we will run several scenarios with varying values of stream flows from the Nile River to see how Egypt will react to changes in water availability. Overall, we intend to make predictions concerning Egypt's current and future levels of vulnerability and resilience.

Variables

Nutrition. The value function for nutrition has a minimum value of 438,000 calories per capita. This value represents the minimum amount of calories per year that an individual can survive on (The World Bank 2013, 1). The maximum value for nutrition is 1,000,000 calories per capita. To put this number into perspective, the US currently uses approximately 950,000 calories per capita (USDA Economic Research Service 2010, 1). The curve of our value function rises at an exponential rate until it reaches 850,000 calories per capita. This curve forms an exponential pattern because even if the population is consuming 500,000 calories, for example, the quality of life is not improving at a notable rate. It is not until the caloric intake reaches about 600,000 that the

added calories begin to drastically improve the quality of life. Nutrition values that exceed 1,000,000 calories per capita indicate a high propensity for obesity and heart disease.

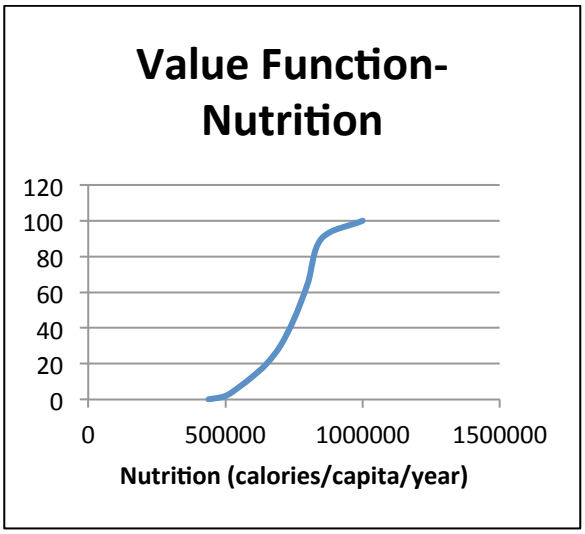

Figure 14. Value Function-Nutrition

Population Growth. The value function for population growth has a minimum value of -5.0 %. According to the results drawn from our model's simulations, this is the value for population growth when Egypt is in a state of collapse. The maximum value is 8.2%. To put this into perspective, the highest current growth rate of any country is Oman with 9.17% (The World Bank 2013, 1). Neither growth rate represents a number that is sustainable for a healthy country. The value function follows a bell curve. This is because it is most desirable to achieve a growth rate that is moderate. A value that is too high indicates that the population will increase beyond the current resources of the country. On the other hand, a value that is too small indicates that death rate is surpassing the birth rate or that emigration is sky-rocketing. We have centered our bell curve around a population growth of zero after referencing thriving nations such as Sweden, Norway, France, and Germany. These nations are very stable and notable for their steady population. A population growth of 0% would give a nation a raw score of 100. Egypt currently has a population growth of 1.6%, therefore, making their raw score around 68.

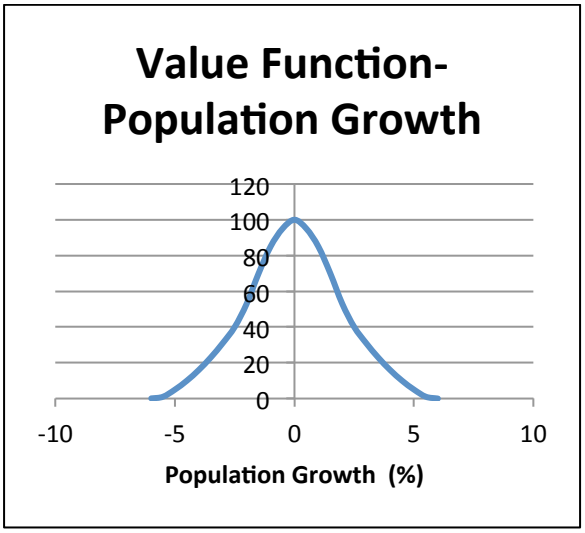

Figure 15. Value Function-Population Growth

Water Surplus. The value function for water surplus has a minimum value of -10 billion m^3 of water. According to the results drawn from our model's simulations, this is water deficit that occurs during a potential national collapse. The maximum value is 10 billion m^3 of water. This value represents the 100% value for this variable. The curve of the value function increases at an exponential rate until it reaches 0 billion m^3 of water. At this point, the variable has achieved 80% of the value. After this value, the curve levels out. This occurs because water is less valuable to Egypt once it has already satisfied its annual water consumption needs. For the purposes of our simulation, a water surplus with a negative value is where our simulations become very sensitive. Our report does not focus on the effects of a water surplus, but

rather the effects that result from decreasing stream flow.

Threshold Values. Threshold values represent the limit that nutrition and water surplus can reach before Egypt undergoes a population collapse. These values have been validated using the simulations from our system dynamics model. The threshold value for nutrition is 438,000 calories per capita per year (The World Bank 2013, 1).

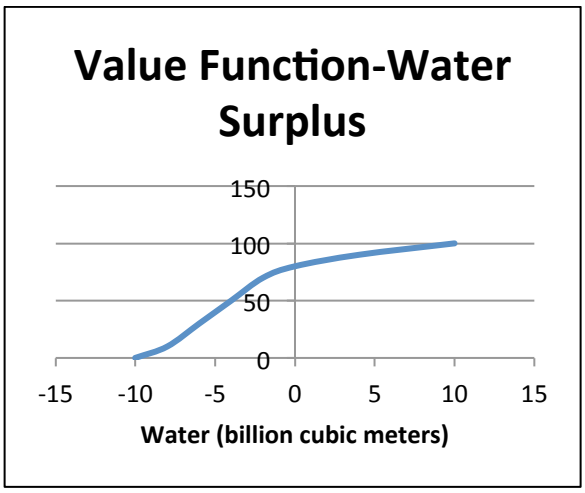

Figure 16. Value Function-Water Surplus

This value is the minimum amount of calories that a person needs to get each year in order to survive. The threshold value for water surplus is 0 billion m^3 of water. Once Egypt's water consumption exceeds their annual supply and reserves, population collapse is imminent.

Our Human Vulnerability index is comprised of water surplus, nutrition, and population growth. These three variables are at the core of our system dynamics model. They comprise our dashboard of indicators, which is used as an estimate of Egypt's of vulnerability and resilience levels. Based on our previous research, our team made informed decisions concerning the weights of each of these variables in order to formulate the Human Vulnerability Index. Weights were assigned based on how important each variable is to the survivability of Egypt. A value function is created for each variable by assigning a weighted score to an observation (Parnell, Driscoll, and Henderson 2011). Essentially, a value function captures stakeholders' returns to scale over a range of actual observations (Parnell, Driscoll, and Henderson 2011). While values in a value function are typically generated by the stakeholders of a model, in this case the weighted values reflect hypothetical estimates of what regional stakeholders might provide. Numbers taken from each variable's value function, when multiplied by their specific weight, will provide output scores for each variable. The sum of these scores determines the overall score for our Human Vulnerability Index.

$$\begin{aligned} &Index\ Score \\ &= (Water\ Surplus\ Score * Weight) \\ &+ (Population\ Growth\ Score * Weight) \\ &+ (Nutrition\ Score * Weight) \end{aligned}$$

Measure weights reflect the weighted scores of the value function. The sum of the measure weights equal 1.0. We ranked nutrition as our most important variable with a weight of 0.4. This is because it directly correlates to the quality of life of each Egyptian. If nutrition drops too low, people will die or be forced to migrate from the country. We ranked population growth as our next most important indicator with a weight of .35 because it gives an indication of the success or failures of Egypt. We feel that it is less important than nutrition because population growth/decline can occur for reasons other than the country's level of vulnerability. Other factors such as the global economy, climate, and disease all affect population growth. Finally, we ranked water surplus as least important with a weight of 0.25. Though water

surplus/deficit drives Egypt's agricultural output and has a direct impact on nutrition, it can be supplemented by outside sources. Improved technology and irrigation techniques can off-set decreased stream flow and can sustain Egypt's levels of vulnerability.

Results

We can use our model to run scenarios that give us insight into Egypt's vulnerability and resilience. Each of the scenarios we introduce is derived from realistic possible circumstances that may occur in Egypt within the near future. Descriptive profiles and corresponding summaries for each scenario are presented in Table 2.

Scenario #1- Baseline

In the first scenario, we hold stream flow at its current value of 84 billion m^3 of water. Our model displays that Egypt will undergo a population collapse of 9 million people in approximately 21 years. The amount of calories consumed per capita per year will dip from 900,000 calories to 407,560 calories in 22 years. From there, our model displays an oscillating pattern in relation to nutrition and population. This occurs because the high death rate during periods of collapse drastically reduces the population, which consequently decreases water consumption. As the population recovers, water consumption increases again, resuming the initial trend of water depletion.

Scenario #2-Increased Consumption from Upstream Countries

The second scenario simulates a situation in which upstream countries, such as Ethiopia and Sudan, increase their water consumption progressively over a 5 year time horizon. This action would deprive Egypt of the stream flow levels, which they are accustomed to. In this scenario, we reduced stream flow by 2 billion m^3 for each of the next five years. The model displays that a population collapse will occur in 16 years, which is 5 years earlier than in scenario #1. Nutrition falls from 900,000 calories per capita to 408405 calories in 17 years.

Scenario #3-Effects of Increased Desalination

The third scenario duplicates the conditions from the second scenario, while assessing the potential of supplementing Egypt's water inflow through desalination. In this scenario, we added an inflow 1 billion m^3 of desalinated water into Egypt's domestic water supply. This addition of water delayed the population collapse from scenario #2 by two years. This indicates that an investment for expanding Egypt's desalination program can have positive effects, but it can't stop an inevitable collapse due to over-population.

Scenario #4- Effects of Filling the GERD

The fourth and final scenario simulates the filling of the Grand Ethiopian Renaissance Dam (GERD), which is scheduled to be complete in 2017. This dam has a maximum capacity of 63 km^3 of water and is expected to be filled over a 15 year interval (FAO Water Reports 2005). This scenario simulates decreased stream flow in Egypt over 15 years as a result of Ethiopia's upstream siphoning from the Nile. The data from our model shows that the filling of the GERD will have minimal effects on Egypt's vulnerability and resilience. The model predicts that a population collapse will occur in roughly the same time period as our baseline scenario. The index score drops only slightly in the first five years relative to our baseline index score. Maybe if the GERD was filled over a shorter time interval (as Ethiopia would desire), we would see a

more drastic effect on Egypt's levels of vulnerability and resilience.

Outcomes for the three key weighted value functions from which our index is comprised are presented in Figure 17 (Nutrition), Figure 18 (Water Surplus), and Figure 19 (Growth Rate).

Scenarios 2 and 3 are arguably the least desirable outcomes while scenario 1 is clearly the most optimal. Increased consumption of water by upstream countries over time will produce detrimental effects on water resource capacity of downstream countries. Scenario 4 (water diversion to fill the GERD) is similar to scenario 1 until 20 plus years out, which suggests that, under the modeling assumptions, filling the GERD prior to 20 years may be preferable in light of continued population growth throughout the region. Figure 21 shows the index values of each scenario over our 25 year time horizon. It is the cumulative representation of our scenario analysis. Scenario 1 consistently maintains the highest resilience score throughout, which validates our interpretation of the data in the previous section.

Scenario 1

In our baseline scenario, we observe the best case for Egypt's future. The index value does not fall below an index value of 50 until year 22. This coincides with a pronounced spike in death rates as is expressed in our population growth data for this scenario.

Scenario 2

This scenario produces the worst case for Egypt's future. The index value falls below 50 in year 12 and then undergoes multiple years of oscillation as the country undergoes extreme volatility from population fluctuation.

Scenario 3

This scenario is slightly better than scenario 2. This comes as a result of an improved desalinization program within Egypt's urban centers along the banks of the Nile River. Unfortunately, such an improvement cannot overcome the creeping decline of the index score as a result of an undue burden on water consumption from population growth. The index value falls below in year 13.

Scenario 4

This scenario is better than scenarios 2 and 3. This outcome validates our hypothesis that the effects of filling the Grand Ethiopian Renaissance Dam over a 15 year period does not negatively impact resilience as much as increased consumption from upstream countries. The index value does not undergo a dramatic decrease until year 17. If Ethiopia were to fill the GERD over a shorter time interval (such as 5 years), the detrimental effects on resilience would be accelerated and more pronounced.

Discussion

Our model has served as a baseline system to help our team understand the dynamic interplay between variables essential to Egypt's wellbeing. The various scenarios run through our model have helped contribute to our understanding as to where gaps exist within the country.

With respect to the first research question, the key indicators modeled were stream flow, nutrition, population, and agriculture. All of these variables are essential to the output of our model. These variables overlap in such a way that changing the

value of one directly effects the output of another. Our model shows that population is greatly affected by the changes in stream flow entered into our model. Variations in stream flow do contribute to all of the variables; however, population variance is an essential output of this model. When the model shows an output in which population drastically decreases, onlookers view this variable as a key indicator to watch.

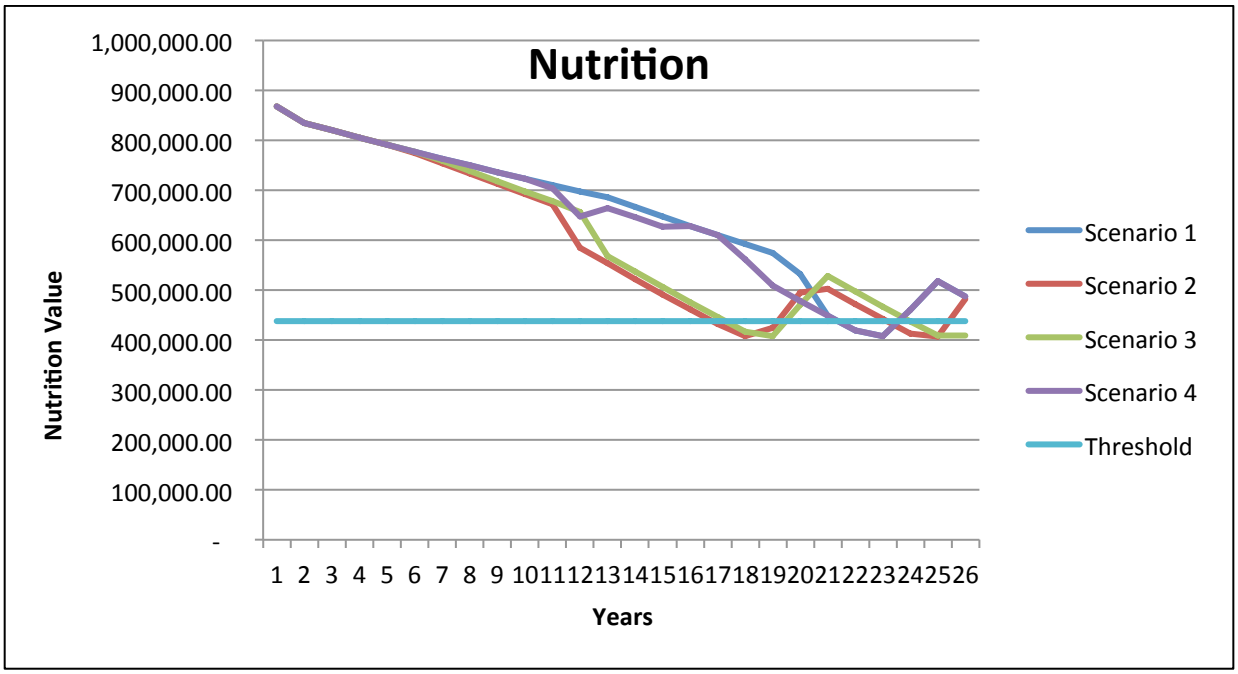

Figure 17: Scenarios vs. Threshold Values

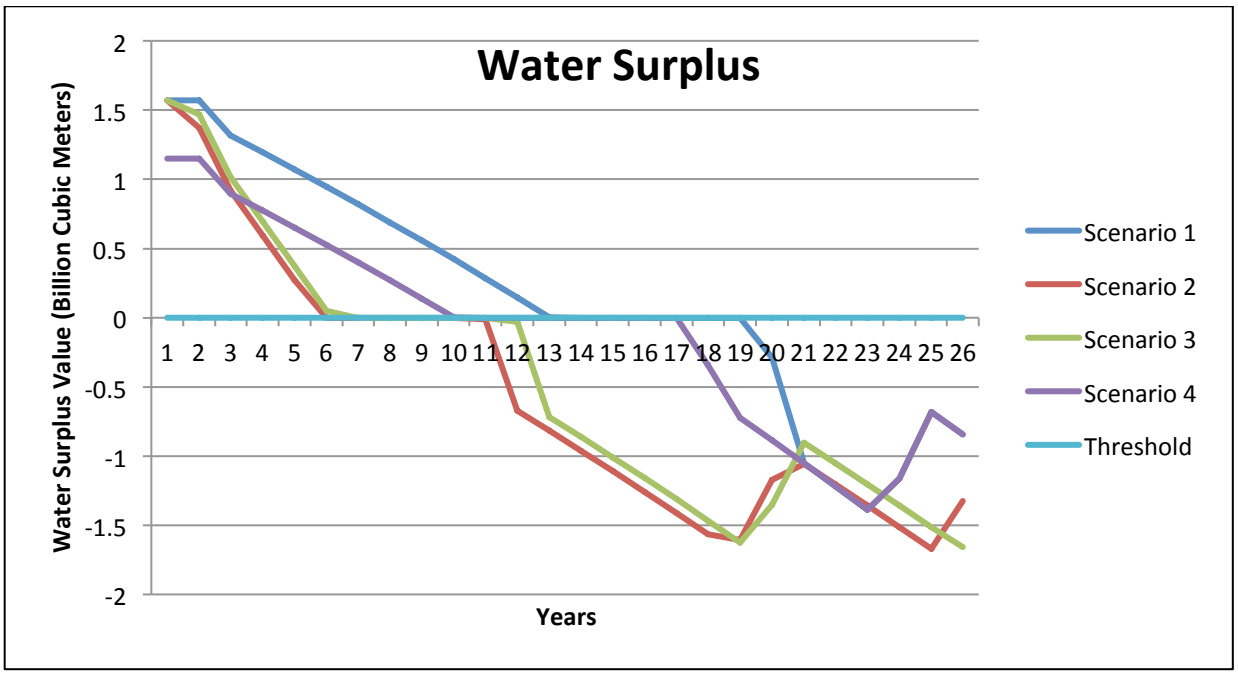

Figure 18: Scenarios vs. Water Surplus

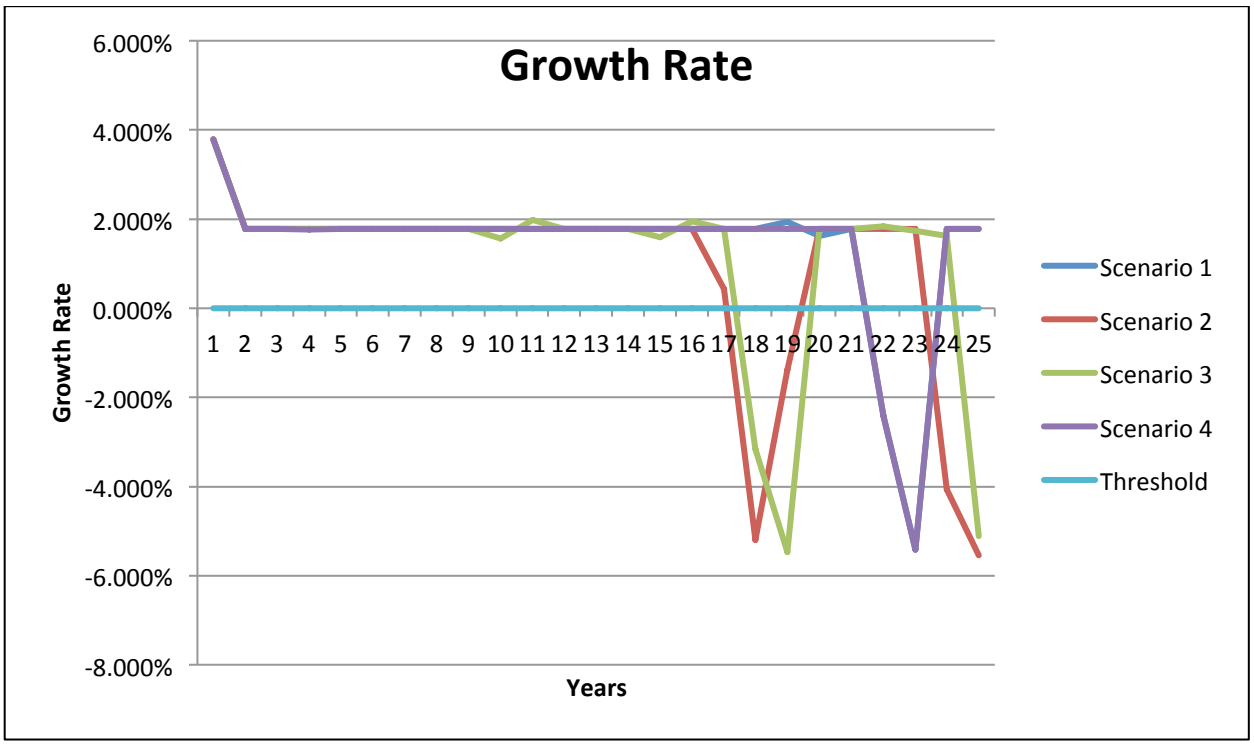

Figure 19: Scenarios vs. Growth Rate

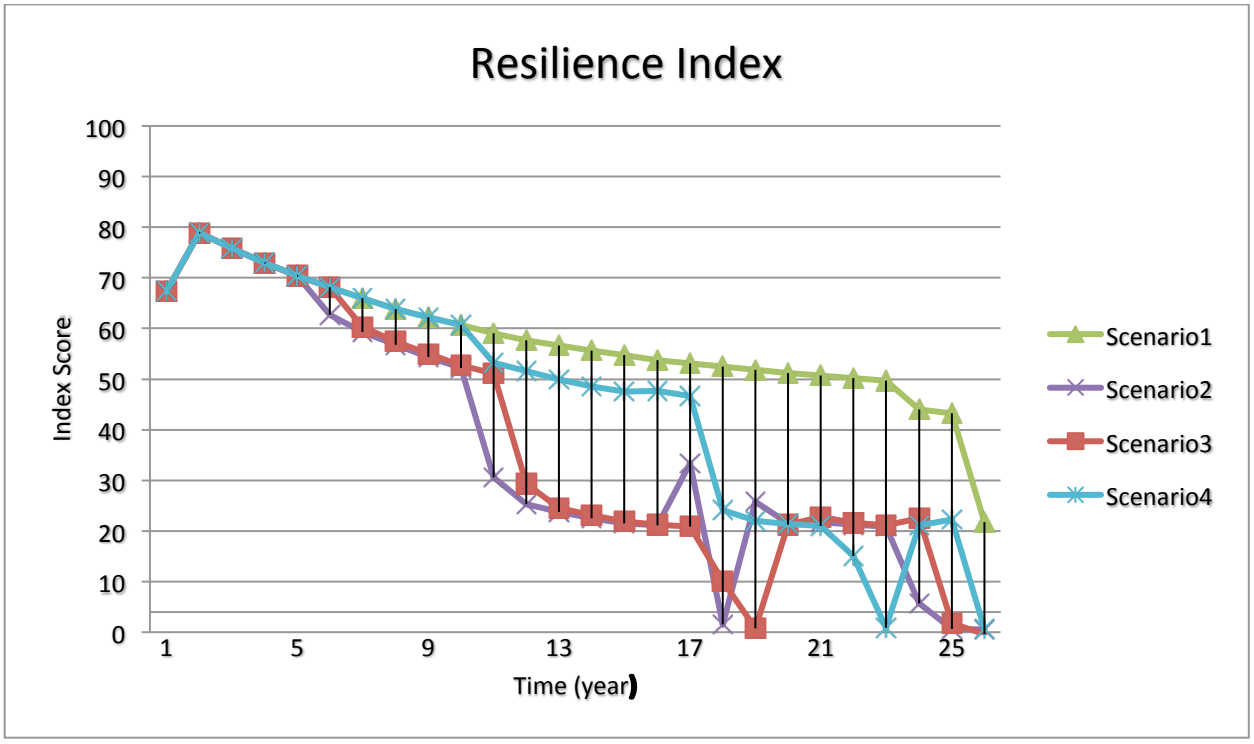

Figure 21. A Comparison of Scenarios as a Measure of Resilience

With respect to the second research question, we sought to find Egypt's score on the Human Vulnerability Index. This is a significant area of study for our team because the various scenarios run through our model affect Egypt's score. This score is useful because it can be used, as a guide to help make policy decisions that will impact Egypt in the short term. Every scenario our group ran resulted in a decrease in vulnerability over a 25 year time horizon. However, as viewed in our team's graphical output, Scenario 2 has the most drastic effects on the overall stability of the country. This is alarming because scenario 2 is a very probable scenario in the upcoming future.

With respect to the third research question, our threshold graphs show when each variable for our scenarios falls below a certain limit. When a scenario crosses a threshold, it indicates to decision-makers that Egypt is in near and certain danger. Through analysis, it is clear that scenario eventually reaches these thresholds. It is only a question of when. Egypt should take measures now to mitigate such failures that will occur in ten or more years. Strategies include investing resources into improving irrigation techniques as well as decreasing national dependency on agriculture.

Taken together, the modeling technique described in this paper potentially provides various stakeholders with an approach to monitor vulnerabilities at the country and regional levels. Output generated by system dynamic models can be incorporated into a set of value functions and used to monitor short and long-term vulnerabilities within a range of plausible outcomes. Stakeholders, to include combatant commanders, can receive regular reports, similar to the one presented below in Figure 20, which illustrate a set of plausible scenarios, corresponding inputs and assumptions, and a graphical display of plausible outcomes given the assumptions of the bounded systems that define the scenarios. Assumptions, key factors, and inputs for one or more scenarios can be modified to detect how actions might enhance or further impede plausible outcomes. While the scenario outputs produced by the models do not predict future outcomes, they do provide stakeholders with a range of outcomes reflective of the model structure.

Conclusion

The water conflict in the Nile River Basin is an issue that will continue to influence policy decisions in the region over the next several decades. Our team's goal was to create a useful and relevant dashboard that both civilian and military commanders can use as a reference when making impactful decisions. This dashboard will present data that informs decision makers as to the state of vulnerability in a country. This will allow these decision makers to understand which indicators and/or key variables may contribute to a country's vulnerability with respect to certain scenarios. For this particular case study, we have found that any decrease in stream flow will advance Egypt from a state of "alert" to one of "high alert". Over the next several decades, there is no telling which regions of the world will require aid from the United States. Our hope is that our research here may help mitigate time and effort, allowing key leaders to make timely and accurate decisions.

Scenarios

1. Streamflow held at current value of 84 billion m³ of water
2. Simulates situation in which upstream countries increase their water consumption over a 5 year time horizon. We reduced streamflow by 2 billion m³ for each of the next five years.
3. The third scenario duplicates the conditions from the second scenario, except we added an inflow of 1 billion m³ of desalinated water into Egypt's domestic water supply.
4. The fourth and final scenario simulates the filling of the Grand Ethiopian Renaissance Dam (GERD), which is scheduled to be complete in 2017. This dam has a maximum capacity of 70 billion m³ of water and is expected to be filled over a 15 year interval. This scenario simulates decreased streamflow in Egypt over 15 years.

		Results				
	Years to Collapse	Water Surplus in 5 years (billion m³)	Nutrition in 5 years (calories per capita)	Population in 5 years (millions)	Index Value in 5 years	Index Value at collapse
Scenario 1	21	9.47	777,370	91.64	68.48	0
Scenario 2	16	0	774,361	91.64	63	0
Scenario 3	18	0.47	777,370	91.64	63.86	0
Scenario 4	21	5.27	777,370	91.64	66.61	0

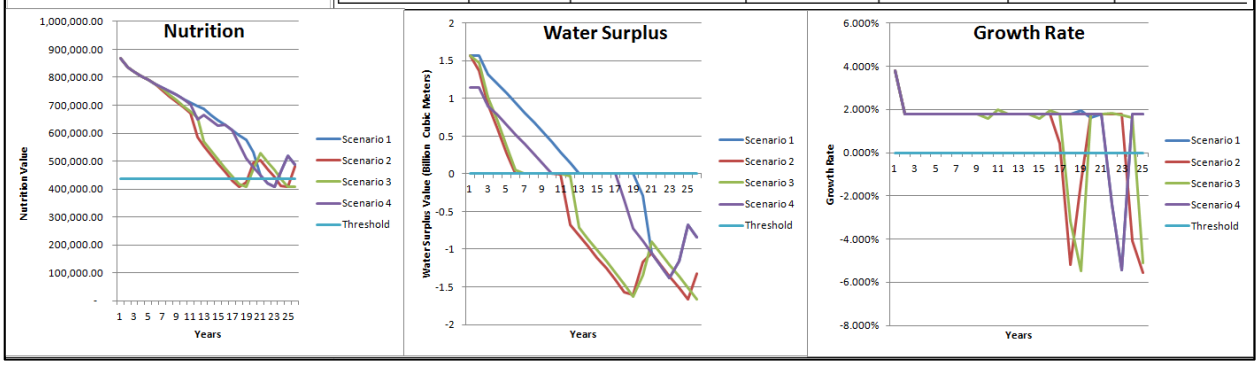

Figure 20: Scenarios vs. Nutrition, Water Surplus, and Growth Rate

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Conflict Incidence & Climate Shock

By Thomas Curran
Advisor: Dr. Amy Krakowka Richmond and Dr. Adam Kalkstein, Department of Geography & Environmental Engineering

"In much of Africa, the prevalence of subsistence agriculture as the primary means of economic productivity exposes these societies to increased distress from climatic changes,"

Incidents of intrastate violence sit at the nexus of a complex web of instigating factors. When a society's resilience is overwhelmed by a combination of these triggers, the risk of armed conflict increases dramatically. Agrarian societies, in particular among the world's economic sectors, are held hostage by the whims of meteorological conditions. Temperature and rainfall variation pose a dangerous gamble for farmers, great harvests and crop failures can be separated by a mere few days of rainfall. When farming practices prove inoperable because of climate conditions subsistence farmers are forced to look elsewhere for income. Such vulnerability is exploited by extremist groups like Al-Shabaab who offer cash bonuses and monthly payments plans that represent the difference between life and death for many young Somali's.

This study evaluates the impact that climate shocks (rainfall) have on rates of violent conflict in differing agrarian societies. Shocks represent periods of rainfall that falls outside the historical average of the region. The two regions of the study, Gedo and Bay, represent a predominantly pastoral and a largely agrarian region respectively. The comparison of these two regions responses to extremes in rainfall provides insight into the relative resilience of different economic bases and can assist in targeting vulnerable areas in the future.

The Rift Valley, Uganda

Review of Literature

This review will include four primary areas of interest: (1) empirical models of climate change and water availability (Africa), (2) affects of climate change on agrarian societies (Africa), (3) empirical studies of water availability and conflict rates, (4) economic rebellion theory concerning causes of intra-state war.

Empirical Models of Climate Change and Water Availability (Africa)

Climates are ever shifting and Africa is no exception. Climatic change in Africa occurs in two main forms: widespread rise in temperatures and the intensification of preexisting rainfall patterns. Rising global temperatures have translated to notably hotter weather in many regions of Africa, most notably in the Sahel and associated latitudes (to include the Horn). (Hulme et al.; Hoerling et al.) These temperatures are controlled by two major influencers, El Nino and the Indian Ocean Dipole.(Bowden and Semazzi) Changing oceanic temperatures and air pressure patterns directly affect continental temperatures. Sea surface temperature differentials across the continent correlate to differing air masses, and thus, temperatures and rainfall; a warmer southern ocean results in a drought whereas a cooler one brings rain. (Hoerling et al.) Currently the continent of Africa is approximately 0.5 C warmer then it was a century ago and it is expected to outstrip world temperature rise over the next century with predictions varying from a 0.2 C to 0.5 C increase per *decade*. (Hulme et al.; Knox et al.) Such temperature rise can be predicted to exacerbate already variable rainfall patterns, intensifying the climatic variation experienced on the continent. (Bowden and Semazzi)

Annual rainfall patterns, in conjunction with temperature variation, are increasing in variation and intensity.(Wheeler and von Braun) Globally total land surface in extreme drought has increased from 1% to 3% with severe jumping from 5% to 10% and moderate moving from 20% to 28%. (Burke, Brown, and Christidis) On the continent of Africa, annual rainfall patterns for the north and east have shown fairly small variability, however, southern regions have displayed high inter-annual variations in both temperature and precipitation. (Hulme et al.) Yet, as changing temperature ranges increase in scale, so too will rainfall variations, leading to intensified droughts and periods of heavy rain. (Hulme et al.; Bowden and Semazzi; "A Climate of Conflict"; Burke, Brown, and Christidis) Rainfall is already decreasing in both the southern and Sahel regions, while increasing in eastern and southeastern Africa, providing just a snapshot of what may come. (Hoerling et al.)

Another factor to consider when analyzing rainfall is inter-annual variation. While annual variation may be small (albeit increasing), inter-annual variability is already large in much of Africa, particularly the Sahel. (Hulme et al.) Increases in such variability represent large swings between drought and heavy rainfall, stressing the existing ecosystems of the continent and potentially exacerbating preexisting tensions internal to nation-states.

The Horn of Africa, the region central to this study's body of work, has demonstrated two primary reactions to changing oceanic influences. Northern areas will experience, "Rainfall deficits that are short-lived and less severe" while the southern region will have, "More severe and perhaps more prolonged rainfall

deficits." (Bowden and Semazzi) A recent of comparison of rainfall in the region has shown the Northern Greater Horn of Africa to be 29% wetter than the previous decade (1990's vs. 1980's) while the Southern region was 19% drier. (Bowden and Semazzi) While it is unlikely that such drastic variation will hold, a long-term pattern of increased rain and drought in the region is likely, testing the resilience of the populations and nations of the area.

With much of Africa dependent on agriculture-based economies, increased climate variability will set the conditions for large-scale negative impacts on the livelihoods for much of agrarian Africa. (Wheeler and von Braun) Such climatic shocks will test the resilience of African societies, threatening to aggravate pre-existing tensions, causing strife to an already vulnerable region.

Affects of Climate Change on Agrarian Societies (Africa)

While the world is currently producing enough food to provide for current population levels, large distances between producers and users combined with poor distribution networks has resulted in nearly 2 billion people being considered food insecure (out of 7 billion). (Wheeler and von Braun) Of those nations experiencing major food stress, "almost all countries in the most extreme "alarming" category [are] situated in sub-Saharan Africa or South Asia." (Wheeler and von Braun)

In much of Africa, the prevalence of subsistence agriculture as the primary means of economic productivity exposes these societies to increased distress from climatic changes, "As climate is a primary determinant of agricultural productivity, any changes will influence crop growth and yield, hydrologic balances, supplies of inputs and other components of managing agricultural systems." (Knox et al.) Rice, wheat, maize, sorghum, millet, cassava, yam, and sugarcane make up over 80% of crops produced in Africa with maize demonstrating the least resilience to climate change.[1] As only four percent of arable land in Africa is irrigated, crop yield will decrease significantly with climate variation. (Theisen et al.) Overall, yield for Africa is projected to be reduced by 8% with maize yield reduced in upwards of 13% for the Sahel and eastern Africa. (Knox et al.)

It is not a far reach to expect that increased rainfall variability and widening temperature ranges will negatively affect stability for livestock in the same way as they affect crop production, and, indeed, this appears to be the case. Periods of drought cause a stress on the capacity of herders to maintain their cattle stock, forcing large-scale sell offs. (Abebe et al.) When such a sale affects a large area supported by subsistence based herding sell offs result in supply outrunning demand and prices plummet. (Maystadt and Ecker) Between 2010-2011 a drought in southern Somalia (the region of this study) caused a regional herd destocking when cattle prices fell nearly 50% over the course of four months. (Maystadt and Ecker) Radical herd composition changes caused by climate shifts have far reaching consequences for those integrated within the herding economic sector. In the same period as the drought, Somalis in Jubaland experienced a purchasing power dip upwards of 60%. (Maystadt and Ecker) With extreme weather patterns predicted

[1] Wheeler and von Braun, "Climate Change Impacts on Global Food Security."

to increase rather than lessen in the coming decades the impact of extreme events on herding will become more substantial. (Burke, Brown, and Christidis) It is becoming increasingly clear that already food insecure regions will become increasingly depleted as climate change impacts agricultural production. (Wheeler and von Braun) Coupled with predicted world population increases, these shortages will intensify resource competition and lead to forced migration, especially as staple food crops become less economically stable.

Empirical Studies of Water Availability and Conflict Rates

Two major bodies of work encompass current theory on water stress and rates of conflict incidence, these are: (a) environmental security literature, (b) raiding theory.

The type, as much as incidence of violence, emerges as a key factor when analyzing climate-conflict theory. Intra-state conflict can be divided into two key domains: tribal (raiding), and civil-war. (Miguel, Satyanath, and Sergenti; Meier, Bond, and Bond) While not perfect, these three classifications allow for the recognition of different types of conflict as the result of differing initial circumstances. It is possible that climatic conditions that support-raiding culture (i.e. increased rainfall in pastoral regions) may have the inverse effect on more developed, or agrarian cultures. Climate-conflict discussions, therefore, must be based in the cultural geography of the region in which the correlation is studied.

The first, "environmental security literature", is characterized by the belief that resource shortages, notably water, will correlate to a high incidence of armed intra-state conflict in developing nations. ("A Climate of Conflict"; Burke et al.) This theory argues that when climatic changes whether long term or as a shock, outstrips the adaptive capacity of a state, violent conflict is probable. ("A Climate of Conflict") Empirical evidence provided in "Warming Increases the risk of civil war in Africa" would support this theory, stating that a 1° C increase in temperature results in a 4.5% increase of civil war, as sampled in Africa. (Burke et al.) Specific examples, notably UN Secretary General Ban Ki-Moon's assertion that "the Darfur conflict began as an ecological crisis," further the environmental security theory. ("A Climate of Conflict") Chief among the factors that influence this violence is temperature, according to Burke, et al. (Burke et al.) As agricultural production is affected communities resort to migration, increasing ethnic tensions, or scramble to control dwindling resources, causing civil war. (Burke et al.; Knox et al.) Subsequent empirical studies have cast doubts on this theory, questioning the methodology of drawing data from the middle of civil wars as opposed to outbreak years, among other concerns. (Buhaug) Thus, while logical, the environmental security theory is not infallible, further empirical evidence is required to support the descriptive arguments already in place.

The second series of empirical studies reject the notion of conflict related to water stress. Rather, this body of work argues that the inverse is true; that conflict rates rise when an area is wetter as the rewards for pastoral raiding tend to be greater. (Meier, Bond, and Bond; Witsenburg and Roba; Theisen et al.; Buhaug) Empirical evidence taken from pastoral conflict areas where raiding is the predominant form of violence point to wet season violence for a variety of reasons, including: more

vegetation allows for greater concealment, increased cattle survivability, better risk/reward ratio, and decreased job availability (dry seasons require large amounts of labor to find water). (Witsenburg and Roba; Meier, Bond, and Bond) Whereas environmental security theory argues that increased water stress correlates with violent outbreaks, raiding theory points to water stress as a cause for increased cooperation between parties, as demonstrated through research in pastoral Kenya. (Witsenburg and Roba) As raiding culture requires significant planning, time, and resource allocation for a successful operation, shortfalls in water will play a limiting factor in the ability of predisposed groups to undertake raids. (Meier, Bond, and Bond)

Irrespective of cause, drought or bounty, the research all suggests that environmental factors are externalities that may multiply the threat of, rather than cause an outbreak of violence. (Buhaug; Theisen et al.) Additionally, the dynamics of conflict, once started, are almost certainly heavily influenced by climate conditions, especially in underdeveloped regions. Government or rebel actions to control water sources may drive neutrals into violence as they seek to survive, intensifying wars. (Theisen et al.)

Economic Rebellion Theory concerning Causes of Intra-State War

Despite whatever idealistic views a rebellion may profess, there is no chance of success if they do not actively seek financing for their operations. To this end, it can be reasonably said that a rebellion operates in the same way as a large criminal organization in that it operates through predatory economic policies. (Collier, "Rebellion as a Quasi-Criminal Activity") Rebels must continually loot and excise taxes (protection, etc.) in order to finance their revolution. Economic capacity, therefore, plays a crucial part in intra-state wars, many times outweighing political grievances as an indicator of potential conflict. (Collier, *1-22*)

The realization, then, is that rebellion has higher incidence rate in states that have export economies relying on the sale of primary commodities but also have generally low economic growth and a poor economy, allowing the rebels to profit from looting the main source of income while reducing the government's capacity to respond. (Collier, *1-22*) Predatory economic theory, therefore, in combination with an instigating economic driver, explains both the initial creation, and subsequent continuation of civil wars. (Theisen et al.)

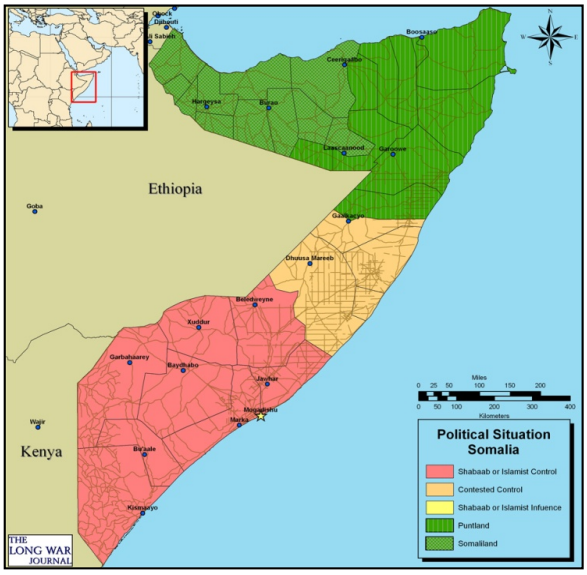
Instigating factors for rebellions typically release a wellspring of pent up frustration and mistrust. Typical causes include the death of a martyr, a flagrantly wrong law or political policy, or extreme heavy handedness by the government. However, other factors can instigate these conflicts as well, including climate variability. (Collier, *1-22*)

As stated previously, the prevalence of subsistence agriculture as the primary economy for much of sub-Saharan Africa leaves it exposed to climatic changes. Weather shocks, in particular, have been shown to greatly impact largely agrarian economies. In sub-Saharan nations, when there is a five point drop in economic growth the likelihood of civil war increases over 50%. (Miguel, Satyanath, and Sergenti) Rainfall variations, particularly when brought to the extremes of drought or flooding, have been shown to cause such economic shocks, reducing livelihoods and

government means to respond (taxation for police, aid). This progression of environmental shock, to economic shock, to intra-state conflict requires the affected society to be heavily reliant upon the agriculture sector of their economy, as is the case for much of sub-Saharan Africa. (Miguel, Satyanath, and Sergenti)

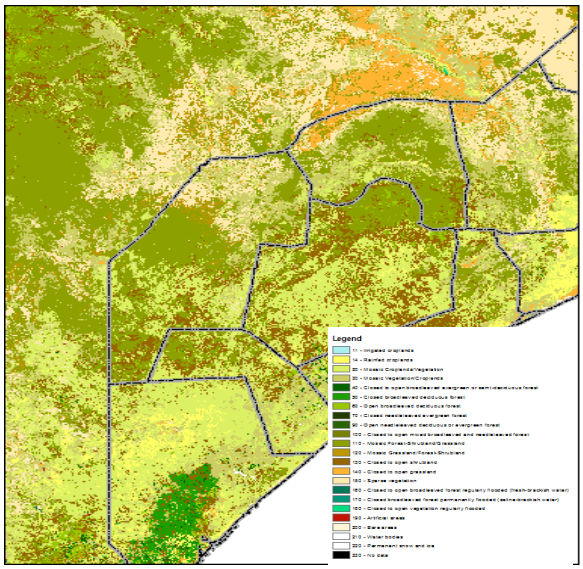
Definition of Study Area:

As a failed state Somalia provides a "sandbox" of opportunity for understanding the complex dynamics that govern the initiation of violent conflict. As with any dynamic and multifaceted phenomena, it is difficult to attribute a singular aspect as the primary initiator of violence, however we can seek to determine "triggers"- factors that exacerbate existing tensions and test a society's resilience.



Map 1a: Political Control in Somalia.("Somali-Kenyan Conflict")

In this case study two regions of Somalia, Bay and Gedo are compared. These regions reside in southern Somalia (Jubaland) and experience similar governing constraints under Islamist control, most notably by the group al-Shabaab (see Map 1a). Additionally, the proximity of the regions and similar geo-physical makeup of their terrain exposes them to much the same climate (see Map 1b).

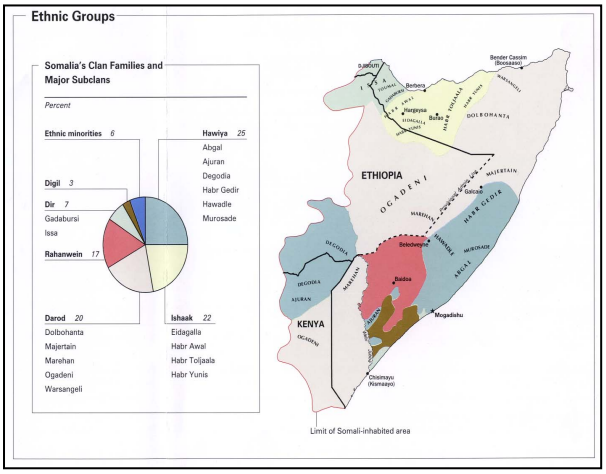


Map 1b: General Vegetation Patterns, Southern Somalia.(DT)

Within these regions, two major ethnic groups dominate the cultural landscape. The Rahanwein and Darod clans, both subgroups of native Somalis compose the majority of the population of Gedo and Bay (see Map 1c). ("Somalia Maps - Perry-Castañeda Map Collection - UT Library Online") The clan structure of the populace provides much of the framework for local governance and interactions between members, allowing us to expect a generally uniform system of values and norms that spans both regions. Economically, the two regions differ greatly. According to calculations published in the *American Journal of Agricultural Economics* (Maystadt et al. March, 2014) the economics base of Gedo is nearly one-half pastoralists whereas Bay's economy is largely dependent on its 80% agro pastoralists.[2] While the difference between the two types of agricultural may seem

[2] (Maystadt and Ecker) March 2014

semantic, it is actually of the utmost importance in understanding economic resilience. Agro-pastoralists, by the nature of their fields, are tied to the land. Pastoralists, contrastingly, are generally nomadic, moving about the land to seek the best vegetation and water sources to maintain their herds. Both groups enjoy differing advantages, which may be exacerbated or threatened by climate conditions. Pastoralists generally are more flexible in avoiding localized climate shocks (i.e. river flooding), however they lack the more pronounced societal structure that grows in conjunction with the more fixed settlements around agro pastoralists. (Campbell)



Map 1c: Ethnicities of Somalia

This study seeks to understand which community is more resilient, the nomadic pastoralists or the fixed agro-pastoralists.

Methodology

The data for this research was compiled from two sources: weather data was prepared by Mr. Jeffrey Zautner of the 14th Weather Squadron USAF, and conflict data through the ACLED database as part of the Robert S. Strauss Center of the University of Texas.

Rainfall data was difficult to obtain because of data collection limitations within Somalia (notably the lack of longstanding and accurate meteorology stations). In order to overcome this limitation, data was resourced through US Air Force models provided by the 14th Weather Squadron. These models provide estimates of monthly precipitation levels based on data collected in neighboring countries, notably Ethiopia and Kenya. The model was able to provide estimates at precise grid coordinates, allowing for monthly rainfall data to be prepared for multiple locations per region. For this study, monthly rainfall data was prepared for two locations in both Bay and Gedo (see Figure 2). The resulting sets of monthly precipitation rates were averaged for each region, providing an estimate of typical precipitation rates over a temporal period of 1979-2014 (see Tables 3-4).

Location	Point #1	Point #2
Bay	3.117890 N, 43.648639 (Baidoa)	2.229662 N, 42.966614 E
Gedo	3.789577 N,42.523155 E (Luuq)	2.701635 N, 41.719665 E

Figure 2: Locations for precipitation data.

A climate shock was determined to be precipitation levels that fell outside one standard deviation of a month's historical average rainfall rate.

In total Bay experienced 37 months of rainfall outside of one deviation out of a total 204 months (1997-2014), yielding a "shock" rate of 18%. Gedo experienced 45 shock months, or, a rate of 22%, which is likely due to Gedo's increased distance from the coast, and, thus, the moderating effects of the ocean.

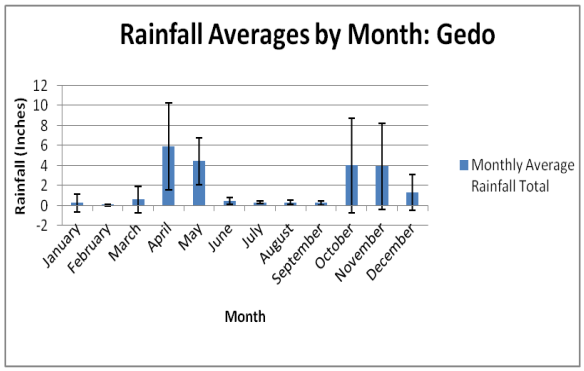


Table 3: Calculation of Average and STD – Gedo

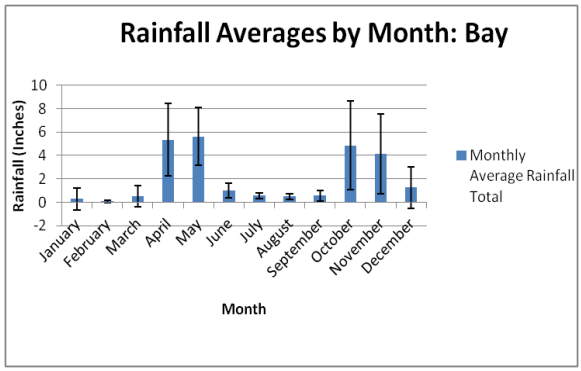


Table 4: Calculation of Average and STD – Bay

Conflict data for this study was provided by the ACLED database, a program which records conflict data globally and is able to provide georeferenced points of violence.

Data gathering, then, is gathered through other means, as explained on the ACLED website, "ACLED data are coded by a range of experienced researchers who collect information from secondary source information primarily and apply the guidelines…to extract information from news reports." ("Methodology | ACLED")

Data from ACLED was pulled for Somalia from 1997-2014. The resulting dataset was sorted by administrative region (see Maps 2a-2b), resulting in 783 incidents of violence for Gedo and 1135 for Bay (Note: not all incidents yielded casualties). Given the significant difference in population between the two regions this is a logical difference in conflict totals. It is important to note that there was a significant increase in "incidents" starting around 2011 for the ACLED database. While this could be attributed to the Kenyan invasion of southern Somalia (to liberate the city of Kismayo) in 2011, the sustained high level of "incidents" makes it more likely that this is merely an increase in reporting frequency. In either case, there is a definite imbalance in the data towards more recent years.

There is some level of skepticism that must be applied when analyzing such a data set due to the inherent "in-sensibility" of the data. That is, whereas you can "sense" temperature or precipitation, you cannot sense violent conflict.

Armed with a list of "shock" months and a list of corresponding conflict incidences per month the final step was to compare shock months with "normal" (i.e. the control) months. As noted earlier, there was significant discrepancy in reporting between early years and late years in the ACLED database. A simple analysis of conflict incidence compared to monthly averages and standard deviation was therefore ruled out as having too much uncertainty. In order to capture a shock month's rate of conflict within the framework of its temporal period the number of conflict incidents in a shock month is compared to the average number of incidents between the years preceding and following the event. For example, if October 2012 was a shock month, then it is compared with the average of October 2011 and October 2013. The resulting difference is classified as either "positive", "negative", or "no change". Years that did not have data for both the year before and after (i.e. 1997 or 2014) were compared against only the year available.

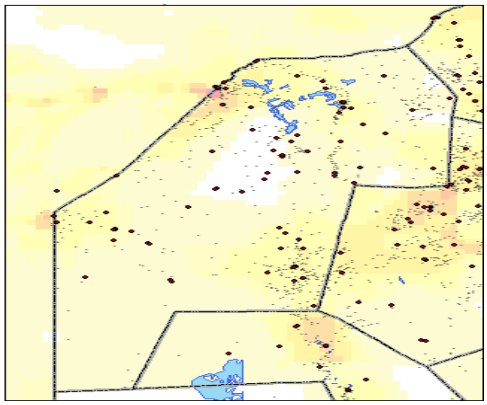


Table 2a: Conflict Incidents – Gedo

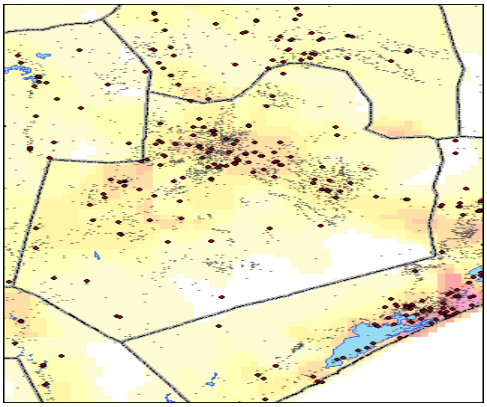


Table 2b: Conflict Incidents - Bay

Results

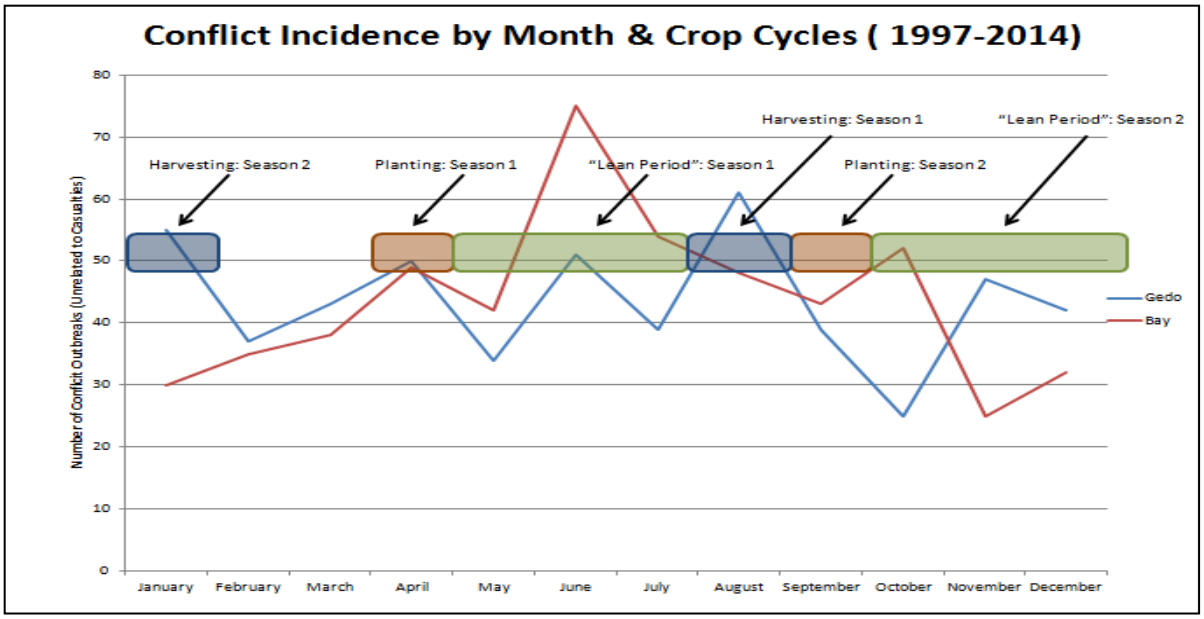
Two significant features became apparent in this this study: 1) a high commonality in the seasonal structure between fighting and crop planting, and 2) distinctively greater stability in the agro-pastoral region then in the pastoral region.

Conflict in Bay and Gedo generally followed a logical progression from an economic activity standpoint.

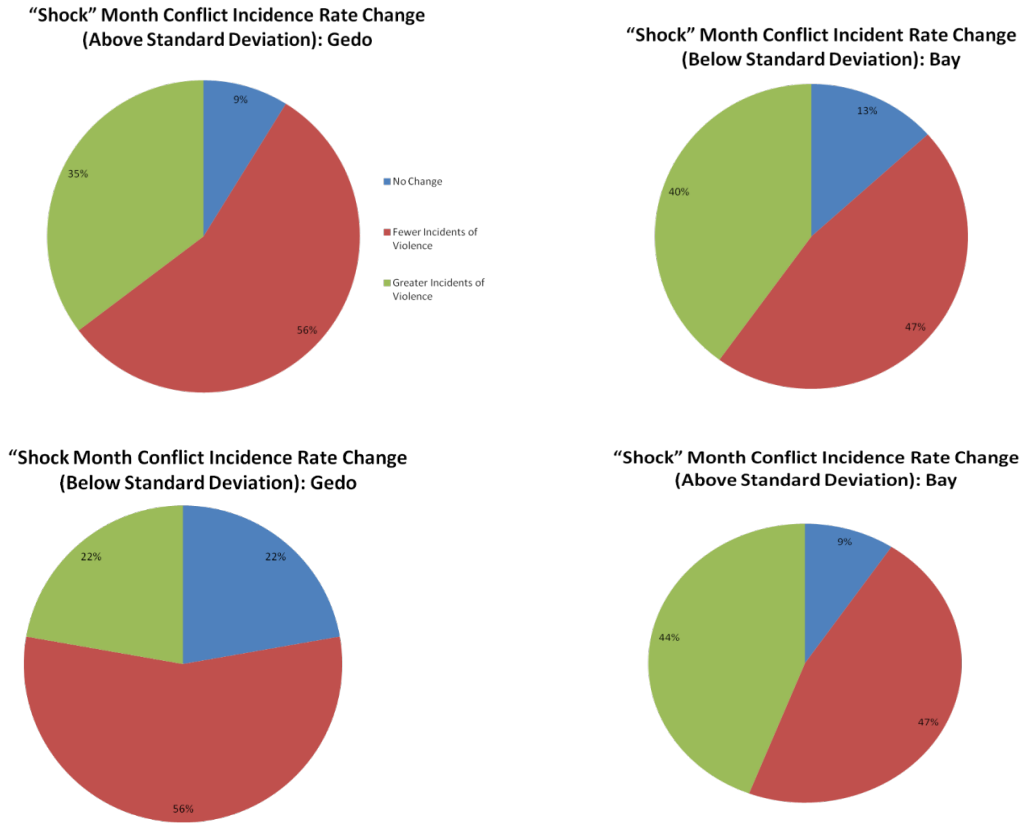
For both regions of Somalia, rainfall follows a generally diurnal pattern, promoting two crop seasons, one from May to August, and a second from October to January (see Figure 1b)("FAO GIEWS Country Brief on Somalia"), which, when disturbed, can cause a marked decrease in conflict rates. Both the pastoral and agro-pastoral regions reacted similarly to the May planting season (increased conflict) but the pastoral region displayed much higher incidents of violence in the second "lean period" that occurs from October-December (see Figure 1a).

The analysis of climate shock and conflict incidence returned a significant difference in response to climate shock between the two regions (see Figures 2a, 2b, 2c, 2d). As demonstrated in the above charts there was no significant increase in violence for shock months above or below the standard deviation. Rather, the predominant disposition was towards conflict reduction, with Gedo having over 50% of all shock months' return a negative value for both flooding and drought and Bay returning an equal 47% of reduction for both. While further study would be needed to prove the cause for this decrease in conflict this may be a result of decreased time (note the conflict incidence rate in "lean periods") available to engage in violent, risky behavior, as agrarian societies scramble to salvage their crops and herds in the aftermath of a climatic disaster.

Additionally, there was little variation in the response based on the type of shock for Bay while there were significant changes for Gedo indicating greater stability in the agro-pastoral region.



Figures 1a/b: A) Conflict incidents per month, B) Crop calendar for Somalia



Figures 2a, 2b, 2c, 2d: The change in conflict incidents during a "shock" month.

Decreases in violence in Bay stayed the same at 47% for both flooding and drought scenarios and increases in violence were only 4% different for flooding scenarios (above standard deviation). This indicates that the community has measures to mitigate and cope with climate shock events, at least enough to stymie a major eruption in violence. The pastoral region of Gedo, contrarily, showed significantly (12% greater) more rates of conflict in times of high precipitation then in times of drought, though decreases in violence stayed the same (all change went to "did not change). This difference indicates that Gedo may be less prepared to handle such disasters, causing a greater dispersion from the norm in a "shock" scenario.

These results do demonstrate that there is a significant difference in the stability between the two regions. Bay, with its more grounded, agrarian population was more stable during times of high rain variability then its neighbor Gedo. This could be the result of the greater social structure that forms around agrarian societies, allowing the creation of social "safety nets" and other avenues of economic opportunity during times of high stress. Additionally, informal trading between clan members who are geographically closer together (in a settled areas) may help to "weather the weather".

Conclusion

As world temperatures rise, large climatic shifts will occur, especially impacting rainfall levels and intensity.(Burke, Brown, and Christidis) In the Horn of Africa this will result in higher rainfall to the north, and a drier south, with both regions suffering from higher intensities of the two extremes: flood and drought.(Bowden and Semazzi) In turn, these weather patterns will negatively affect crop yield, particularly maize and other staple crops.(Knox et al.) As subsistence agriculture is the primary economic sector for both Gedo and Bay, the negative yield brought about by climate shocks will adversely affect the economic resilience of the region, however it will not translate to increased rates of conflict. Rather, the addition of these stressors will negatively impact conflict incidence, presumably because engaging in risky behavior is only economically rewarding when there are little opportunity costs (i.e. fighting during a "lean period"). Further, the amount of change we can expect will vary by the predominant agrarian practice of the area. In areas with more grounded agro-pastoralists there will be a significantly dampened effect compared to purely pastoral regions. While currently unconfirmed, it seems reasonable to attribute this to the greater capacity for "social security nets" that comes as part of the development of grounded societies, a social structure lacking in nomadic pastoral groups.

In the complex wheel of conflict, climate change is only one spoke. Yet, major shifts in climate have, and will continue to, increase the importance of that spoke. Increased research into the causation of these conflicts and the relation of temperature and precipitation patterns will help us to further understand and mitigate these risks.

Avenues for Future Research

This work, while it provides significant groundwork for understanding the interplay of conflict and rainfall, leaves plenty of room for future enhancement. More advanced methods in statistical analysis to control for a wide variety of

factors (proximity to water sources, etc), the elimination of interclan conflict, and the inclusion of actual rainfall data (as opposed to projections) would all allow for validation of the model and increased capacity to point to a correlation between climate shock and conflict.

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1929 Water Basin Agreement Impact Analysis

By Shawna Moore
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"Currently, the Nile River supports a population of approximately 200 million people throughout the entire basin."

The Nile River, among the world's most significant waterways, supports the irrigation and hydro-electric power needs of an estimated 200 million people living in the approximately 3,350,000 square kilometer Nile River Basin.[1] The 6,700 kilometer river travels through eleven East African countries, commonly referred to as the riparian states.[2] The Nile River has two main tributaries, the White Nile and the Blue Nile, with eighty five percent of the total water flow originating in Ethiopia. Despite Ethiopia's persistent claims to absolute sovereignty of the waterway, the international community has recognized Egypt as the dominant force in the region permitting near complete Egyptian control of the river.[3] Egyptian Nile policy relies on claims of "historical rights" to the waterway, imperative for Egypt to protect riverine integrity. Since the colonial period, Egyptians have accomplished this by preventing any use or contamination of the river by the upper riparian states. Egypt's domination of the Nile, today, is based on a political and legal foundation built by Great Britain during the colonial era.

The Nile, Uganda

[1] Kwasi Kizito Obeng, "The Long Jewel: Assessing Political Solutions to the Nile River Conflict by Maneuvering Around Colonial" (Ph.D. diss., Clark Atlanta University, 2012): 1-40.

[2] Alice Shih and Trevor Stutz, "Sink or Swim: Abrogating the Nile Treaties While Upholding the Rule of Law" (2012), *Student Prize Papers,* Paper 106.

[3] Aaron Tesfaye, "Conflict and Cooperation and the Evolution of the Nascent Nile Basin Regime," *Northeast African Studies*14, no.1, (2014): 123-144.

When present in the region, the British aspired to control the Nile to the fullest extent in order to protect their economic and strategic interests in Egypt. Of all actions taken by the British, the 1929 Water Basin Agreement was the most influential. This agreement established *de facto* Egyptian sovereignty over the Nile and granted Egypt legal veto-power over any water projects attempted by other riparian states or colonies. This agreement served as the critical antecedent to the 1959 Water Agreement, which further enshrined Egyptian hydro-political control through the post-colonial era. The 1929 and 1959 legislation determined Nile water usage until increased demand for water resources, significant changes in the regional economic landscape, and Egyptian instability in the 21st century spurred initiatives to renegotiate the terms of regional Nile River usage.

In the late nineteenth century as Great Britain extended its Empire by establishing colonies throughout Africa, the British Government took extensive measures to secure unrivaled control of the Nile River. Great Britain intended to reap the economic benefits associated with an expanding Egyptian economy and unrestricted access to the Suez Canal. The Suez Canal, opened in 1869, shortened trade routes between British ports and prominent trade hubs such as Bombay and Calcutta by several thousand miles. This reduction in transit distance increased trade profitability by decreasing both duration and risk of travel. In a speech to the House of Commons, Anthony Eden, 1st Earl of Avon and future Foreign Secretary, spoke of the importance of the Suez Canal. He said the canal was the, "Back door to the East, … [and] the front door to Australia, New Zealand and India…[It was], in fact, the swing door of the British Empire which [needed] to keep continually revolving if [British] communications [were] to be what they should."[4] In order to achieve what the British viewed as the necessary extent of control over the Suez Canal, they occupied Egypt in 1882 and imposed harsh colonial rule.[5] Initially, Britain's primary strategic interest was to secure the Suez Canal to optimize trade profitability. British officials soon began to realize that dominance of the Nile was necessary to secure the Suez Canal against interference from other colonial powers, for the glory of the British Empire, and to demonstrate the advancement of science and reason.[6] Exemplifying this idea, Evelyn Baring, Earl of Cromer and British Controller-General in Egypt, described the Nile strategy as insuring that, "The waters of the Nile, from the lakes to the sea, are brought fully under control it will be possible to boast that man, in this case the Englishman, has turned the gifts of Nature to the best possible advantage."[7] Great Britain extended its colonial reach beyond the Egyptian borders pursuing control in Sudan and surrounding upper riparian states. Ethiopia was among the only kingdoms successful in withstanding British colonization efforts throughout the late 19th century. In the newly acquired lands, Great Britain imposed indirect

[4] Jane Gifford, "Extracting the Best Deal for Britain: The Assassination of Sir Lee Stack in November 1924 and the Revision of Britain's Nile Valley Policy," *Canadian Journal of History* 48, no. 1, (Spring-Summer 2013): 87.

[5] Gifford, "Extracting the Best Deal for Britain: The Assassination of Sir Lee Stack in November 1924 and the Revision of Britain's Nile Valley Policy," 87-100.

[6] Scott O. McKenzie, "Egypt's Choice: From the Nile Basin Treaty to the Cooperative Framework Agreement, an International Legal Analysis," *Transnational Law & Contemporary Problems*, (2012): 571-600.

[7] Terje Tvedt, "Hydrology and Empire: The Nile, Water Imperialism and the Partition of Africa," *Journal of Imperial & Commonwealth History*, (2011): 182.

control caring to only put forth the minimum resources and effort needed to secure the uninhibited flow of the Nile.[8] Successful empirical expansion was a key step toward ensuring Egyptian hydro-political control, but the British were not as shortsighted to assume these measures were enough. They recognized the long-term value in endowing their claims and pursuits with legal legitimacy through treaties and colonial decrees.

Imposing western laws and diplomatic tradition, British officials wrote and forced the acceptance of treaties and agreements, creating a patchwork of documentation and regulations. In 1891, Great Britain and Italy agreed to clarify spheres of influence over East Africa to prevent Italian intrusion in the Nile River Basin and assure expansion for both European empires without the threat of war with each other.[9] Both empires realized that war in Africa could be detrimental, so they opted to agree to this peace assurance. This measure became the first of many significant legal steps designed to limit outside interference with British monopolization of the Egyptian water supply. In evaluating possible threats, the British recognized the potential for Ethiopia, in possession of the headwater of the White and Blue Niles, to interfere with British plans. On May 5, 1902, in Addis Abba, British and Ethiopian officials reached an agreement whereby the British recognized Ethiopian independence and Ethiopia relinquished all claims to usage of the waterway.[10] Article III of the document reads, "His Majesty the Emperor Menelik II, King of Kings of Ethiopia, engages himself towards the government of His Britannic Majesty not to construct, or allow to be constructed, any works…which would arrest the flow…[of] the Nile."[11] Failures in translations, speculated to have been intentional on part of the British, drastically reduced the effectiveness of this agreement. Though the overarching trade-off was understood, details were highly disputed. While the British understood the term "arrest the flow" to refer to interference with the waterway affecting flow in any way, the Ethiopians believed this wording only prohibited actions that halted water flow altogether.[12] To this point, Great Britain's attempts to monopolize the waterway on behalf of its Egyptian colony lacked clarity, thus were ineffective in establishing unrivaled dominance over the Nile to secure complete water security. Great Britain continued pursuing legislative measures, next with the 1906 Tripartite Agreement between Great Britain, Italy, and France. This document enumerated the unified mission to protect Egyptian interests in the Nile River Valley. Agreement among European colonial officials proved to be largely ineffective. Far removed from everyday colonial life, these policymakers developed nonspecific policies that did little to thwart illegal utilization of the waterway.[13] Despite

[8] Walter Rodney, "How Europe Underdeveloped Africa," in *Beyond Borders: Thinking Critically About Global Issues*, ed. Paula S. Rothenberg (New York, NY: Worth, 2006): 100-110.

[9] Terje Tvedt, *River Nile in the Age of the British: Political Ecology and the Quest for Economic Power* (London, GBR: I.B. Tauris, 2004), 55-79.

[10] Taylor W. Henshaw and Richard K. Paisley, "Transboundary Governance of the Nile River Basin: Past, Present and Future," *Environmental Development* (2013): 59-71.

[11] Ferede Wuhibegezer and Abebe Sheferawu, "The Efficacy of Water Treaties in the Eastern Nile Basin," *Africa Spectrum* 49, no. 1 (2014): 59.

[12] Henshaw and Paisley, "Transboundary Governance of the Nile River Basin: Past, Present and Future," 59-71.

[13] Emmanuel B. Kasimbazi, "The Impact of Colonial Agreements on the Regulation of the Waters

multiple attempts, the pre-World War I British Empire still lacked the manpower and legal ability to regulate and enforce total control of the Nile.

The British Empire expanded after Germany's loss in WWI, and interwar Great Britain attempted to tighten its grip of the Nile. In 1929, Great Britain instituted the Water Basin Agreement. This treaty legitimized Egyptian control over the Nile River and eliminated loopholes in the preceding legislative framework. Egypt had won nominal independence in 1922, and existed thereafter as a technically sovereign protectorate of Great Britain. Great Britain maintained its hydro-imperialist aspirations, and continued to bolster its economic domination of its former colony.[14] Instability in Egypt could be detrimental to European profits, so Britain exerted control subtly, both indirectly and directly.

Even prior to the 1929 treaty, the British Government allocated significant time and resources to analyze the status of the Nile region and options for the future. A 1920 London study confirmed the necessity for expanded water resources to support the Egyptian economy and way of life.[15] Egypt boasted the largest population in the region, and relied heavily on the Nile River to support national water needs, mainly for agriculture. In comparison with other riparian states, Egypt received significantly less rainfall so its freshwater resources were limited, almost entirely, to the water flow of the Nile. This climatic difference among the riparian states was the basis for millennia of Egyptian claims to natural rights to the Nile.[16] British officials projected that water uncertainty could provoke regional tensions, further inflaming an unstable land. Within Egypt, nationalist and independence movements were expanding and intensifying. Outside of Egypt, Sudanese revolutionaries were pursuing total independence.[17] The unknown status of Sudan inspired some Egyptians to follow suit, and seek full independence from Great Britain. Despite these growing nationalist movements, the British Government refused to relinquish its economic and political power, although it did attempt to appease the Egyptians by backing the government's claims to the Nile.[18]

The 1929 Water Basin Agreement between Great Britain and Egypt explicitly enumerated the rights granted to Egypt regarding Nile River control. It was the first treaty to place significant power in the hands of the riparian self-governing state, as opposed to only colonial rulers. Originally, the agreement was formulated as an exchange of notes between the Egyptian Prime Minister, Mohamed Mahmoud Pacha, and the British High Commissioner in Cairo, Lord Lloyd.[19] The provisions of the agreement aimed to protect Egyptian interests in the Nile River

of the River Nile," *Water International*, (2010): 718-732.

[14] Tvedt, "Hydrology and Empire: The Nile, Water Imperialism and the Partition of Africa," *Journal of Imperial & Commonwealth History*, 173-194.

[15] Tvedt, *River Nile in the Age of the British : Political Ecology and the Quest for Economic Power,* 55-79.

[16] Alice Shih and Trevor Stutz, "Sink or Swim: Abrogating the Nile Treaties While Upholding the Rule of Law," Paper 106.

[17] I.H. Abdalla, "The 1959 Nile Waters Agreement in Sudanese-Egyptian Relations," *Middle Eastern Studies* 7, no.3 (1971): 329-341.

[18] Tvedt, *River Nile in the Age of the British: Political Ecology and the Quest for Economic Power,* 55-79.

[19] McKenzie, "Egypt's Choice: From the Nile Basin Treaty to the Cooperative Framework Agreement, an International Legal Analysis," 571-600.

Valley by creating what would become known as "water security." Several clauses, specifically, redefined regional water usage by giving Egypt final veto power and outlining the very limited toleration for Sudanese water extraction. The treaty also specified that precisely 92.3% of the river's water flow would be reserved for Egyptian use, leaving the remaining percentage for Sudanese usage and extraction. During the dry season, however, all water would be allotted to Egypt alone, meaning no other riparian state was authorized any usage. Paragraph 4(b) of the document granted Egypt the authority to veto any future Nile development initiatives. Egypt maintained the, "Right to vote on development in the upstream territories without any corresponding restriction on [Egypt's] own freedom of development."[20] This clause effectively gave Egypt complete control of the Nile River. In no uncertain terms, the British agreement established explicit legal Egyptian hydro-hegemony. In accordance with international precedent, Egypt would maintain the powers granted through this agreement, despite eventual independence in the British colonies.

International recognition of the 1929 agreement resulted in Egypt's dominance of the Nile River Basin.

Their history of reliance on the Nile allowed Egypt to claim natural rights to the water source.[21] Before the 1929 agreement, this was Egypt's only defense protecting its monopolization of the river. With the 1929 legislation, Egypt became first riparian state to effectively take formal action claiming ownership of the waterway thus, the international community recognized the legitimacy of their control. The inter-national community accepted the agreement, even though it was only a bilateral accord between a colonial power and a single riparian state. At this time during the Colonial Era, Great Britain was a vast empire and controlled a significant portion of the world economy. The international community feared retaliation from the British Government if they spoke against the 1929 agreement. The British could have interpreted challenges to the legitimacy of the 1929 agreement as an act of aggression. No country was willing to risk severing political and economic ties with Great Britain to protect the rights of states in the Nile River Basin. In short, British economic and political power carried the day.

The legally founded power of Egypt resulting from the 1929 agreement was further expanded upon in the 1959 Agreement for the Full Utilization of the Nile Waters. Together, these treaties established the legislative framework that would remain effective through the post-colonial era until the 21st century. Egypt ratified the 1959 Agreement for the Full Utilization of the Nile Waters to appease Sudan by slightly redefining water usage standards previously outlined in the 1929 agreement. The 1959 document altered allocation amounts and made Egyptian control numerical and concrete. The latter agreement was the first to be signed in the post-colonial era between two riparian states, and stood as the foundational guide in the region for decades to come.

Gaining independence in 1956, the state of Sudan aspired to construct a series of dams along the river in order to increase hydro-power capabilities and national water

[20] Korwa G. Adar, and Nicasius A. Check, *Cooperative Diplomacy, Regional Stability and National Interests: The Nile River and the Riparian States,* (Pretoria: Africa Institute of South Africa, 2011), 36-44.

supply. The proposed project would violate the 1929 agreement, whose legitimacy went unrecognized by the new Sudanese Government. Sudan claimed that the agreement,

Gave no consideration to the interests of Sudan…therefore the Government of Sudan refuses to accept the Agreement…as a criterion for what it does or refrains from doing concerning the waters of the Nile.[22]

According to international precedents at the time, recognition of treaties and agreements signed by a nation must be maintained despite any governmental succession. Treaties could only be abrogated by means of mutually consented rejection, lapse of time, or by legal revocation.[23] The newly sovereign Sudan showed every intention to proceed without hesitation, but the international community only halfheartedly intervened on Egypt's behalf. Initial diplomatic efforts were ineffective. Egypt took active measures to challenge the Sudanese initiative and began pursuing the construction of the Answan Dam in order to increase its own irrigation capabilities and supply hydroelectric power to the region. To progress with construction, though, the Egyptian government needed the approval of Sudanese officials because the backflow of the dam would infringe on Sudanese territory. Amidst rising tensions, neither country wanted to acquiesce and approve the other's project. Fierce debate eventually yielded to negotiation, resulting in the 1959 Agreement for the Full Utilization of the Nile Waters, which both sides viewed as mutually beneficial.[24]

Passed in conjunction with a handful of other diplomatic measures mending ties between the states, the five-part 1959 agreement explicitly detailed water allocation of the Nile by dividing the entirety of the water supply between Egypt and Sudan. Egyptian usage was limited to 55.5 billion cubic meters (bcm) annually, while Sudanese usage was capped at 18.5 bcm. Egyptian reliance still far outweighed that of any other riparian state, so this compromise, though asymmetrical, met the needs of both parties considered. If the annual flow of the Nile fell below the projected value in the future, a Joint Technical Committee would redefine allocation standards between Egypt and Sudan to maintain regional peace.[25] It is also important to note that the preamble to the 1959 agreement stated that the agreement would not void the previous 1929 legislation, only build upon previous terms to explicitly outline exact water distribution proportions as an expansion of the prior precedent.[26] This agreement was extremely important because it validated Egyptian control once again, but without British influence. Though regionally powerful in the late 2th century, Egypt did not have the worldwide political or economic dominance to parallel that of Great Britain during the Colonial Era. Thus, the international community did not have strong personal interests demanding they side with Egypt, should a riparian state

[22] Abdalla, "The 1959 Nile Waters Agreement in Sudanese-Egyptian Relations," 334.

[23] Alice Shih and Trevor Stutz, "Sink or Swim: Abrogating the Nile Treaties While Upholding the Rule of Law," Paper 106.

[24] Claire Cookson-Hills, "The Aswan Dam and Egyptian Water Control Policy, 1882-1902," *Radical History Review*, (2013): 59-85.

[25] Abdalla, "The 1959 Nile Waters Agreement in Sudanese-Egyptian Relations," 329-341.

[26] Adar and Check, *Cooperative Diplomacy, Regional Stability and National Interests: The Nile River and the Riparian States,* 36-44.

have challenged the legitimacy of the 1929 Water Basin Agreement. After Great Britain relinquished control of its colonies in the region, the international community may not have supported Egypt's claims to the waterway. The 1959 agreement effectively revalidated the tenants of the 1929 agreement and reinforced Egyptian regional dominance. Egypt and Sudan enacted the 1959 agreement without the sponsorship of Great Britain or any other external state, so it became much more difficult for riparian states to contest the applicability and validity of Egyptian claims to control over the Nile River. As a result of international legitimacy attributed by the 1959 agreement, the Egyptian Government did not fear challenges to their legal authority, so Egypt exercised their power throughout the 21st century without restraint.

Egypt exercised its authority throughout the post-colonial era by acting upon the principle of *de facto* sovereignty and utilizing its veto power, as established by the 1929 and 1959 legislative framework. International financial institutions fell in line because they recognized Egyptian legal authority and the possible financial benefits that could result from maintaining strong ties with Egypt, the wealthiest and most stable state in the Nile River Basin. The World Bank and International Monetary Fund (IMF), for example, would not proceed with funding for a water project proposal along the Nile until they obtained consent from Egypt.

Ethiopia's Tana-Beles Project failed to gain necessary external funding after Egyptian rejection. The Ethiopian initiative intended to draw and distribute water from Lake Tana, a primary source of the Nile River, for national use. Strategically located dams would allow water to be transported through the Beles River and create irrigation capabilities for upwards of 20,000 farmers.[27]

Concerned about the prospect of reduced water flow, Egypt blocked the project by exercising its influence over the African Development Bank (ADB) to prevent necessary financing. Egypt's actions demonstrate the nation's ability to veto the initiatives of other riparian states and control development in the Nile River Basin.[28] To further cement its control of East Africa, Egypt went so far as to establish several regional organizations to promote Pan-African unity within the Nile River Valley during the post-colonial era, one such being "Ugundu." Despite requests by virtually every member state, Egyptian dominance of Ugundu prevented the organization from addressing matters concerning renegotiation of utilization of the Nile. Egypt's intention was to only focus on social, political, and technological ties among East African states, without relinquishing any power of authority over the Nile River.[29]

Despite economic and political fluctuations, Egypt remained largely stable in comparison to other riparian states throughout the 20th century. This enabled the empire to maintain international recognition of legitimacy and legislative control of the Nile as established by the 1929 and 1959

[27] Terje Tvedt, *The River Nile in the Post-Colonial Age: Conflict and Cooperation Among the Nile Basin Countries,* (London: I. B. Tauris, 2010), 36-44.

[28] Tesfaye, "Conflict and Cooperation and the Evolution of the Nascent Nile Basin Regime,"123-144.

[29] Henshaw and Paisley, "Transboundary Governance of the Nile River Basin: Past, Present and Future," 59-71.

agreements.[30] In 1952, Gamal Abdel Nasser and a group of fellow young military officers organized and executed an overthrow of the Egyptian Government. Nasser became the second president of Egypt preaching Arab socialism, positive neutrality, nationalism, and staunch opposition to colonialism and international influences. The 1959 Water Agreement was passed during President Nasser's reign and is considered one of his most successful accomplishments. His largest failure, though, was a military defeat in 1967 by Israel, which led to the end of his presidency. In 1970, the era of President Anwar Sadat began. Sadat's economic policy was ineffective and led to foreign debt, high inflation, and structural imbalances.[31] Sadat's policy failures caused him to lose much of his initial support, which concerned him greatly, especially with the implementation of the two party system in 1976.[32] In attempts to ensure he retained power, Sadat took extreme measures and arrested numerous political prisoners and supporting fundamentalist Islamic groups to counter leftist opponents. In 1981, though, President Sadat was assassinated by fundamentalist army officers and replaced by President Hosni Mubarak. Mubarak's initial year in power, known as the honeymoon period, instilled great hope for change in Egypt with the release of political prisoners, collaboration of economists for reform, and return of freedom of the press. His sweeping positive changes quickly subsided though, and he fell in line with the legacy of corruption and designed policies to benefit only the wealthy elite. Despite seemingly violent power transitions through military coup-d'etats and partial policies, Egypt remained fairly stable throughout the second half of the 20th century, especially when compared to the surrounding states.[33]

Egyptian regional dominance, however, may be reaching its end as increased demand for resources, growing Egyptian instability, and changes in the region's socioeconomic landscape act in conjunction to undermine the 1929 and 1959 agreements. Increased water demand among Nilotic countries is challenging Egypt's claim to natural rights. Population growth is an integral factor in projecting water needs of the future. Currently, the Nile River supports a population of approximately 200 million people throughout the entire basin. Growth rates are projected to rapidly increase over the coming decades, with estimates of the regional population reaching 400 million by 2025 and 1 billion by 2050.[34] Specifically, populations in Ethiopia and Sudan are projected to grow disproportionately, with the population of Ethiopia predicted to reach 127 million residents by 2025.

By this analysis, the population of Ethiopia will substantially exceed the population of Egypt in the coming decades. Estimates show that half of each country's population is primarily dependent on the Nile for its livelihood; thus, the demand for increased allocation of resources per state, especially

[30] Tesfaye, "Conflict and Cooperation and the Evolution of the Nascent Nile Basin Regime,"123-144.

[31] Galal Amin, *Egypt in the Era of Hosni Mubarak* (Oxford, England: Oxford University Press, 2011), Section 8.

[32] Jerzy Zdanowski, *Middle Eastern Societies in the 20th Century* (Newcastle, UK: Cambridge Scholars Publishing, 2014), 114-118.

[33] Galal Amin, *Egypt in the Era of Hosni Mubarak* (Oxford, England: Oxford University Press, 2011), Section 8.

[34] Kasimbazi, "The Impact of Colonial Agreements on the Regulation of the Waters of the River Nile," 718-732.

in Ethiopia, is expected to heighten drastically.[35] As a result of this regional demographic shift, Egypt will no longer be able to monopolize the waterway based on necessity. Climatic factors further threaten the Nile's ability to meet the demands of the region. Rising average temperatures and expanding regional desertification from global warming will increase crop hydration requirements and water consumption per household.[36] The effects of these increases will undoubtedly be compounded by exponential population growth trends, necessitating expanded irrigation projects to establish productive farming and living conditions throughout the entire Nile River Basin. Irrigation and hydropower expansion projects can no longer be focused solely in Egypt for national benefit and protection. In fact, riparian states have already begun expanding irrigation of arid land within national borders without Egypt's consent. Ethiopia, for example, pursued an initiative to build several hundred small dams. The goal of this project was to expand the area of irrigated land from the current 200,000 hectares to a significantly larger percentage of the 3,600,000 hectares of arable land in Ethiopia.[37] Many attempts by riparian countries to increase water supplies are now acts of desperation because the hydrology of the Nile River is becoming exceedingly uncertain. Projections vary greatly between esti-mates. In the coming decades, the total water flow could experience changes anywhere from a 30% increase in water flow to over a 70% decrease.[38] The worst scenario would undoubtedly be devastating to the entire region, but even the best scenario will not provide sufficient resources to meet the growing water needs of the Nile Basin. With the impacts of global warming compounded with exponentially growing population rates, it is apparent that there is now a humanitarian necessity to renegotiate the water usage terms in the Nile.

Though still the most dominant force in the region, Egyptian domestic instability in the 21st century has lessened the power gap among the riparian states. As described previously, Egypt experienced political and economic fluctuations throughout the 20th century. The rest of the region, however, experienced war and extreme poverty at the time, making Egypt appear to be stable in comparison. The regional political landscape has shifted in the 21st century, though. Growing political stability among many riparian states now exists in stark contrast with the situation in Egypt.

This dramatic political revolution was the public face of a host of economic and social problems.[39] Mubarak's reign left the country battling major downfalls including increased corruption, alienation of the youth and youth unemployment, division among the Egyptian elite, oppression of political freedoms, and economic exclusion.[40] The legitimacy rendered by international support of Egyptian hydro-hegemony is quickly waning as confidence

[35] Ashok Swain, "The Nile River Basin Initiative: Too many Cooks, Too Little Broth," *SIAS Review of International Affairs* 22, no.2 (2002): 293-308.

[36] Dale Whittington, John Waterbury, and Marc Jeuland, "The Grand Renaissance Dam and Prospects for Cooperation on the Eastern Nile," *Water Policy* 16, no. 4 (2014): 595-608.

[37] Swain, "The Nile River Basin," 293-308.

[38] Alice Shih and Trevor Stutz, "Sink or Swim: Abrogating the Nile Treaties While Upholding the Rule of Law," Paper 106.

[39] Galal Amin, *Egypt in the Era of Hosni Mubarak* (Oxford, England: Oxford University Press, 2011), Section 8.

[40] Dina Shehata, "The Fall of the Pharaoh: How Hosni Mubarak's Reign Came to an End," *Foreign Affairs* 90, no. 3 (May/June 2011): 28-32.

in a stable Egyptian future fades and the international community has diminished vested interests in maintaining positive economic and political relations with Egypt. Egyptian unrest has weakened its regional influence making it exceedingly difficult for the government to continue enforcing the 1929 and 1959 legislative framework. Egyptian leaders recognize this shift and, out of desperation, have resorted to threatening adversaries with military action should they infringe on Egyptian control of the Nile.[41]

On January 25, 2011, hundreds of thousands of Egyptian citizens of varying ethnicities and religions took to the streets and demanded for President Hosni Mubarak's immediate resignation.[42] After violent attempts at use of force and Mubarak's refusal to resign, the angry mob of Egyptians began marching toward his residence, vowing to remove the president by whatever means necessary. Both regional and international forces have capitalized on the opportunity to extend their reach in times of diminished Egyptian stability and economic dominance. The Egyptian government has issued statements claiming that any utilization of the Nile resources would be considered a direct act of war against Egypt, but these threats seem to be little more than rhetorical flourishes because the government does not have the means or support to enforce these claims.[43]

Ethiopia, in particular, has taken aggressive actions despite Egypt's warnings. The Ethiopian Grand Renaissance Dam, officially proposed in 2011, was the most substantial of a series of aggressive Nile River initiatives by both Sudan and Ethiopia. The five billion dollar project proposed the construction of a massive upstream dam to regulate flow of the Nile and provide hydro-power to a greater portion of the region. The Ethiopian Government made it very clear they have every intention of pursuing the project, regardless of Egypt's opposing stance. Formerly limited by poverty and economic instability, Ethiopia now claims it now, "Has the economic strength to marshal the financial resources needed to proceed unilaterally with the construction of the dam project."[44] Ethiopian Prime Minister Meles Zenawi also issued a statement directly to the Egyptian people clearly establishing that, "Ethiopia has reached a stage where it can build its own dam with its own money."[45] Ethiopia is not the only actor willing to disregard the historic regional status-quo. International funding organizations such as the World Bank, IMF, and private corporations have begun financing Nile development endeavors without Egyptian approval.[46] The international support that previously attributed legitimacy to Egyptian claims to control over the Nile has faded, effectively making Egyptian veto power over Nile development largely un-impactful.

The combination of increased water needs due to population growth and global

[41] Daniel Epstein, "The Nile Flows South: Egypt's Uncertain Future," *Harvard International Review* 35, no.4 (Spring 2014).

[42] Jason Browlee, "The Decline of Pluralism in Mubarak's Egypt," *The Journal of Democracy* 13, no. 4 (October 2002): 6-14.

[43] Dereje Zeleke Mekonnen, "The Nile Basin Cooperative Framework Agreement Negotiations and the Adoption of a 'Water Security' Paradigm: Flight into Obscurity or a Logical Cul-de-sac?" *European Journal of International Law* 21, no.2 (2010): 421-440.

[44] Whittington, Waterbury, and Jeuland, "The Grand Renaissance Dam and Prospects," 598.

[45] Whittington, Waterbury, and Jeuland, "The Grand Renaissance Dam and Prospects," 598.

[46] Alice Shih and Trevor Stutz, "Sink or Swim: Abrogating the Nile Treaties While Upholding the Rule of Law," Paper 106.

warming, Egyptian domestic instability, and growing challenges and pursuits of development by riparian states necessitate the official abrogation of past agreements and new negotiations to redefine Nile River control. Regional cooperation initiatives have existed since the late 1960's with organizations such as "Hydromet" established in 1967, "Ugundu" established in 1983, and "TecoNile" established in 1992. These groups failed to incite progress because they did not included all of the riparian states and only focused on technological advances without consideration of foundation changes to the legal framework. The 2002 Nile Conference Series (1993-2004) accounted for these shortcomings, and initiated the first wave of change by unifying political and academic representatives for inter-disciplinary collaboration.

The Nile Basin Initiative (NBI), an intergovernmental organization established in 1999, resulted and became a mechanism for transition by promoting multilateral political, economic, and technical reform. The NBI focused on a shared vision program and a subsidiary actions program.[47] The prior tenant encourages regional compromise and collaboration, and the latter tenant aims to create tangible improvements through technological and legal advancements.

These initiatives came to fruition with the Cooperative Framework Agreement (CFA), initially proposed in 1997. The agreement centers on ideas of equitable utilization and water security. According to the tenants of the document, each state should have the right to reasonable utilization of water resources within their own territory so long as the state does not risk significant harm to other riparian states. Lower riparian states, especially Egypt and Sudan in particular, vehemently opposed this agreement because it did not protect absolute riverine integrity.[48] The Egyptian and Sudanese Governments supported the addition of a provision preventing any state from challenging the water security of another, but this proposed addition was denied. Despite powerful opposition by the lower riparian states, the CFA was ratified in 2011 when Burundi became the sixth and final signatory needed to support the upper riparian states and enact the agreement.

Without support from Egypt, Sudan, and the other lower riparian states, the CFA will not be effective rule of law. Unanimous regional support is necessary to successfully redefine control and usage of the Nile River. The CFA did succeed in reinforcing counter-hegemony momentum as negotiations continue, though.[49] With the ratification of this agreement, the upper riparian states asserted their power and dedication to change. Egypt can no longer claim unrivaled *de facto* sovereignty over the Nile River because there now exists conflicting rule of law in the region. In response to this power shift, there was an escalation of tensions in 2011 when the CFA was ratified.[50] Ethiopia aggressively

[47] A. E. Cascao, "Changing Power Relations in the Nile River Basin: Unilateralism vs. Cooperation?," *Water Alternatives* 2, no. 2 (2009): 245-268.

[48] M. S. Salman, "The Nile Basin Cooperative Framework Agreement: a peacefully unfolding African spring?," *Water International* 38, no. 1 (2013): 17-29.

[49] Abadir M. Ibrahim, "The Nile Basin Cooperative Framework Agreement the Beginning of the End of Egyptian Hydro-Political Hegemony," *Missouri Environmental Law and Policy Review* 18, no. 2 (2011): 1-32.

[50] Michael P. Link, Piontek Franziska, Scheffran Jürgen, and Janpeter Schilling, "On Foes and Flows: Vulnerabilities, Adaptive Capacities and

pursued their Grand Renaissance Dam initiative with total disregard for Egyptian opposition. Egypt viciously threatened Ethiopia and other upper riparian states with acts of war, should they continue to pursue Nile development initiatives. De-escalation of tensions began with the election of Egyptian President Abdel Fattah el-Sisi in 2014. President Sisi avoided hostility and, instead, advocated for the recommencement of peaceful regional negotiations.

On March 24, 2015, a trilateral Declaration of Principles was signed by Ethiopia, Egypt, and Sudan. This agreement marks a historic turning point in the Nile River Basin because it ensures Egypt will turn away from threats of war and prioritize a commitment to joint regional initiatives.[51]

This agreement marks the first instance of Egyptian acquiescence, and will hopefully spur a new era of regional cooperation and innovative solutions after decades of hostility.

The unrest in the Nile River Basin throughout the past century is a result of asymmetrical control of the Nile River established by the 1929 and 1959 agreements. The 1929 Water Basin Agreement was the first legislative action taken that granted any state official rights to the Nile. The agreement established *de facto* Egyptian sovereignty over the Nile, granted legal veto-power over any competing water projects, and acted as the antecedent to the 1959 agreement. After WWII, Great Britain gradually relinquished control of its colonies and the Nile became the home of newly sovereign states still bound by the 1929 Water Basin Agreement. To appease growing Sudanese power, Egypt consented to the 1959 agreement and granted Sudan limited ability to utilize the Nile in return for Sudan's acceptance of the legitimacy of the 1929 agreement. The two treaties justified unrivaled Egyptian regional dominance through the 20th century, but climatic, demographic, political, and developmental challenges in the 21st century have forced Egypt to come to terms with the limits of its power. Recent cooperation, especially between Ethiopia and Egypt, paves the way forward for a promising future in the Nile River Basin. The region is still vulnerable to political regime changes and evolving initiatives in riparian states. In order to ensure long term stability, the riparian states need to construct and ratify an agreement similar to the CFA, but with unanimous support. All states must agree to adhere to new policies of water allocation that take into consideration changing regional circumstances and water demands in order to officially draw an end to the Egyptian hydro-hegemony established by the 1929 and 1959 legislative framework.

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[51] Solomon Dersso, "The tension-ridden hydro-politics of the Nile," Al Jazeera, last modified April 2, 2015, accessed April 29, 2015, https://en-maktoob.news.yahoo.com/tension-ridden-hydro-politics-nile-075541009.html.

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Landslides in the Bududa District Building Community Resilience

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"Promoting resilience helps in decreasing the destruction of life, property, and livelihood."

Abstract

Landslides are an accepted natural hazard for communities around the world, in particular those in the Bududa District of Uganda. Although mass movements naturally occur, land use techniques such as deforestation and undercutting of slopes drastically increase the risk and the frequency for these events. Thus, prevention techniques and methods are applicable especially within developing regions that are particularly susceptible to the damage inflicted by mass movements. Promoting resilience helps in decreasing the destruction of life, property, and livelihood. How have actions taken by the people in the Bududa District increased the risk of landslides over the past decade and what policies can be emplaced to create more resilient communities? This study evaluates why landslides are occurring within the Bududa District and finds that soil composition, slope angles, and precipitation effectively cause landslides within this region. However, anthropologic contributions through deforestation and excavation significantly contribute to the frequency, intensity, and overall risk from landslides. Next, the Bududa District is evaluated by looking at communities' economic development, social capital, community competence, and information/communication systems. Communities can increase their resilience by diversifying incomes, promoting large-scale education programs, and strengthening local institutional response capabilities. Moreover, vulnerability can be decreased by reforestation programs, zoning regulations, and hazard risk mapping.

Introduction

Landslides are an accepted natural hazard for communities around the world, in particular those in the Bududa District of Uganda. Although mass movements naturally occur, land use techniques such as deforestation and undercutting of slopes drastically increase the risk and the frequency for these events. Thus, prevention techniques and methods are applicable especially within developing regions that are particularly susceptible to the damage inflicted by mass movements. Promoting resilience helps in decreasing the destruction of life, property, and livelihood. How have actions taken by the people in the Bududa District increased the risk of landslides over the past decade and what policies can be emplaced to create more resilient communities? The aim of this study is to answer this question. First, it will investigate where and why landslides occur within the Bududa District with a focus on the specific factors that increase the risk of landslides. Then, it will describe resilience, particularly in regards to landslides. Lastly, the current state of resilience in the Bududa District will be evaluated so that final recommendations can be made. This study predicts that the

natural factors of soil composition, precipitation, and slope angles are exacerbated by human activities putting people lives and livelihoods at risk. Moreover, the current state of resilience in the Bududa District is lacking in regards to economic development and communication infrastructure while social capital allows people to cope with frequent landslides.

The Bududa District

The Bududa District, located in Eastern Uganda, is situated along the steep slopes of the Mount Elgon volcano. Formerly, it was known as the Manjiya County and was part of the Mbale District. In 2006, Parliament established the Bududa District. It comprises of one county, seven sub-counties and one town council. Geographically, the 275 km^2 district is bound by latitude 2° 49' N and 2° 55' N, longitude 34° 15' E and 34° 34' E (Figure 1). Altitude ranges from 1300 to 2850 m above sea level along the southwestern foot slopes of Mount Elgon, an extinct Pliocene shield volcano (Knapen et al., 2005). Although the Mount Elgon is basaltic, the majority of the district is dominated by weathered granites of the Basement Complex (Davies, 1957).

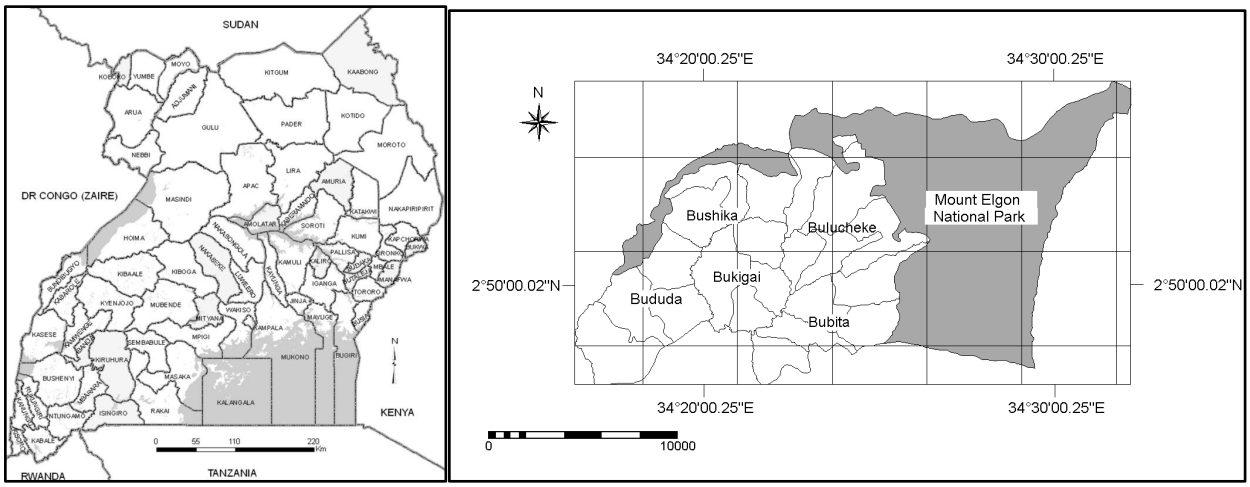

Figure 1: Map displaying the Bududa District's location in Uganda (Knapen et al., 2005)

In terms of climate, the annual average precipitation is 180mm (Aryamanya-Mugisha, 2001) which arrives during two distinct wet seasons from March to June and Late August to November (Knapen et al., 2005). The majority of precipitation collects into the Manafwa River which drains in the Lake Kyoga swamps in the southeast. Soils within this area are classified as Acrisols, Ferralsols, Nitrisols and Luvisols according to WRB classification (Deckers et al., 1999). Vegetation, mainly forests, throughout the district has drastically decreased over the past 80 years and now constitutes 45% the land cover (Knapen et al., 2005).

In 2010, the total population reached 167,000 with 162,975 of it being rural (Directorate of Water Development, 2010). Regardless of the rural majority, the steep slopes have an average population density of 952 people per km^2 making it one of the most densely populated areas within Uganda (UBOS, 2013). Parishes in the west are on the higher end with population

density of more than 1300 people per km^2 (UBOS, 2013). Estimations give each person 32 m^2 of land holdings that are usually steeper than 80% (Knapen et al., 2005). With a growth rate of 3.8%, land scarcity within this region is becoming a larger problem (Kitutu, 2010). The Bududa District, historically, has been settled for the medium to high agricultural potential. Nowadays, people here grow bananas, yams, cassava, maize, coffee, and beans.

Where do Landslides occur and what type are they?

Notable Areas

Landslide data within Bududa District is scarce and poorly recorded on a local and national scale. However, a GIS study performed by Knapen (2003) recorded 98 landslides, mainly debris slumps, in which 11 million m^3 of slope material was displaced. They did this by performing a field study in which scarps as classified by Varnes (1978), could be identified. Further investigations were done using GPS, measuring tapes, and clinometers while accounts of their impact were acquired through interviews with local farmers. Of the 98 landslides, 51 were determined to have occurred from 1997-1999. 24 were before 1997 and 17 from 1999-2002.

Knapen et al. (2005) were able to divide the district into four distinct zones based on concentration and distribution of landslides (Figure 2). The Bukigai zone, a centrally located carbonatite hill, displayed no trace of mass movements. Similarly, the Bududa/Bushika zone, the western area, displayed fewer landslides as well. However, high population density results in a large impact from any landslide. The steep slopes in the east, the Nusu Ridge zone and the Bukalasi zone, experience the highest number of landslides according to this study. They are also impacted although their population density is lower.

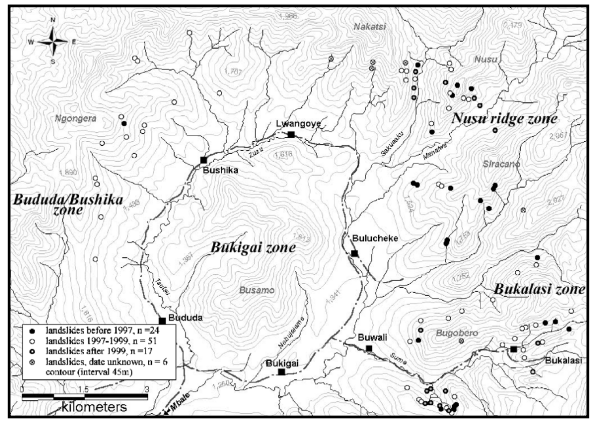

Figure 2: Distribution of Landslides, 1970-1999 (Knapen et al. 2005)

Since the 2002 field study, there have not been any projects of similar scale. Yet, there are many other reports detailing the causes of these landslides. The most notable event since 2002 occurred on 1 March 2010 in Nametsi village. Located within the Bukalasi zone, this landslide occurred along the border with Mount Elgon National Park to the east. Killing 365 people and destroying three villages along with a community center, this event sparked further interest into this vulnerable district (NEMA, 2010).

Landslide Type and Size

Most of the recorded landslides could be classified as a rotational movement in debris, a mixture of rock fragments and fine earth (Knapen et al., 2005). These landslides are able to be identified because they exhibit are large and deep. Smaller landslides go unaccounted for because the land area is resurfaced and cultivated. Although all types of landslides, as defined by Varnes (1978), were identified within the district, the dominate type was a rotational movement which has "a nearly vertical and deep scarp, multiple clearly

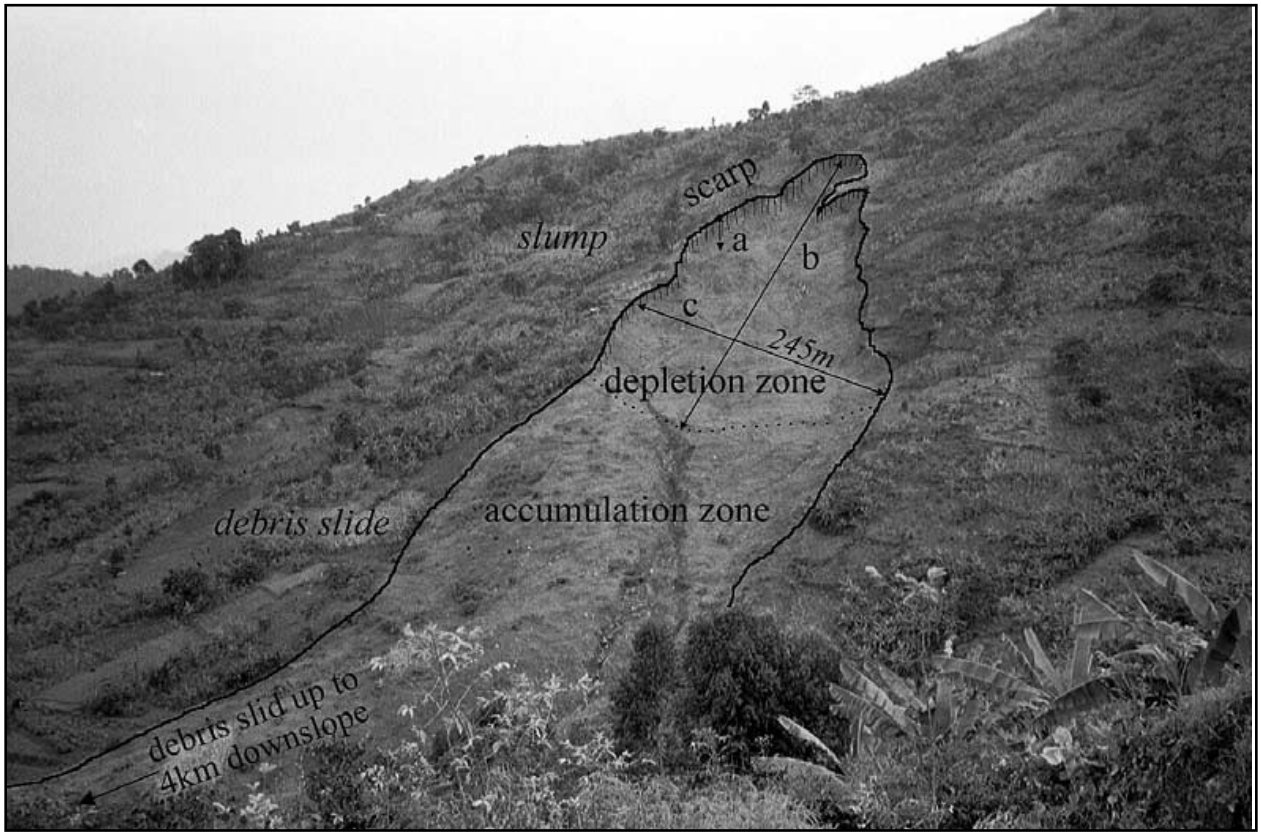

Figure 3: Typical rotational landslide within the Bududa District (Knapen et al., 2005)

visible reverse slopes with pools and water stagnation in the depletion zone" (Knapen et al., 2005). An example of a typical landslide can be seen in Figure 3In regards to size and dimensions, the two largest landslides in the field study dominate 80% of the total 11 million m^3 displaced (Knapen et al., 2005). Yet, the minimum displaced volume was 120 m^3 and the mean was 116,203 m^3 with a standard deviation of 826,010 m^3. Although the two large landslides account for a lot of volume, 50,000 m^3 is enough volume to cover an American football field at a depth of 9.34 meters.

What factors contribute to landslide occurrence?

The factors which contribute to landslides within the Bududa District can be divided into three categories: preconditions, preparatory, and trigging factors.

Preconditions, as Henderson (1997) describes, are the geologic factors of the region. These include type of soil and the orientation of the materials and slopes. Preparatory factors involve human activities like deforestation and excavation. Triggering factors are morphological causes such as seismic activity, erosion, and precipitation (Henderson, 1997). All three of these categories contribute to the frequency of landslides within the Bududa district. However, most studies have found that precipitation is the most influential factor. Nevertheless, that does not discount the impact of other factors.

Preconditions

As previously discussed, the preconditions exist as passive factors often facilitating the start of an event when given an adequate triggering factor.

Soils

Soils have a large impact on the frequency of mass movements because when coupled with large amounts of precipitation, the weight of a slope can drastically increase. In terms of a causal factor, the most important soil properties are how a soil "[influences] the rate of water movement in the soils and the capacity of the soil to hold water" (Kitutu, 2010). More specifically, a soil's particle size and pore distribution help determine how easily a soil can become saturated. For example, finer soils, like clay, tend to hold higher volumes of water due to higher porosity but lower permeability (Kitutu, 2010). A 10% clay threshold, according to Mugagga et al. (2011), creates conditions for "expansion potential." Not surprisingly, the Bududa District is covered with clay rich soils. Ollier and Harrop (1959) determined that two soils series occur in this region. The Bududa Series, red clay loams originating from Mount Elgon, and the Bubutu Series, non-lateritised brown sandy clay loams from Basement Complex Granites, both have high clay content (Ollier and Harrop, 1959). Sidle et al. (1985) further states that higher clay content in deeper soils increases water holding capacity which cause long term movements as well as more extreme slope failures. The Nametsi village site, after soil tests, observed clay content exceeding 32%, which as stated earlier is significantly above the threshold (Mugagga et al., 2011). Thus, the Nametsi site, along with other regions within the Bududa District display "extremely high expansive potential" (Mugagga et al., 2011).

Naturally, the type of soils throughout the Bududa district correlates with the frequency of landslides. Knapen et al. (2005) and Claessens et al. (2007) determine that the east and the west (Nusu Ridge/Bukalasi and Bududa/ Bushika) display unstable soils as compared to the central region (Bukigai). Bukigai, an inactive landslide area, is dominated by acrisols and ferralsols, physically stable soils without swell-shrink properties (Claessens et al., 2007). Yet, this region has a lower population density in comparison to the other regions due to the low fertility of the soil. In the Bududa/Bushika zone, nitisols, soils with slight swell-shrink properties, dominate the region with soils reaching up to 52% clay content (Claessens et al., 2007). Yet, these soils are not the most expansive soils compared to some in the Nyeri district (Kenya) (Claessens et al., 2007). Within the Nusu Ridge/Bukalasi zone, many soils exist but there is a "distinct boundary between the soil and the underlying [bedrock]" which acts as a shear plane when water accumulates (Knapen et al., 2005). Overall, soils within the landslide active zones increase their likelihood through soil properties and soil orientation. In the Bududa/Bushika zone, high clay content traps water while in the Nusu Ridge/Bukalasi zone, planes exist which allow shearing to occur with the added weight of accumulated water.

Slope Steepness

Slope steepness is extremely important in determining the size that a landslide will occur because it correlates with the force of gravity. On a slope, gravity can be broken down into two components: the perpendicular component and the tangential component. The perpendicular component holds an object in place on a slope while the tangential component causes "shear stress parallel to the slope

that pulls the object in the down-slope direction parallel to the slope" (Kitutu, 2010). The angle of the slope determines the strength of each component in relation to the other. A flatter slope will yield a higher perpendicular component while a steeper slope will produce a higher tangential component. Thus, measuring slope steepness helps understand how much stress is on the land. Slopes are measured with gradients on a scale from 0-90°.

In regards to the Bududa District, slopes are not uniform from hill to hill. Therefore, a range is created using the maximum and minimum slope gradients in which landslides have occurred. Knapen (2003) determined a wide range from 14-41°. Kitutu (2010) notes how 14° is one of the lowest thresholds across East Africa (Table 1). This opens the possibility to other factors further exacerbating existing conditions.

Preparatory

Preparatory factors are characterized as human activity, which can increase the risk of landslides occurring in conjunction with preconditions.

Excavation

Excavation typically accompanies human development within an area during the construction of roads, buildings, mines and quarries, dams and reservoirs, canals, tunnels and communication systems (UNESCO/UNEP, 1988). The basic idea behind this preparatory factor is that it weakens the base of a slope, which in turn increases the effect of the tangential stress on the slope. This ultimately decreases slope stability and makes areas vulnerable to triggering factors.

Location	Slope	Author
Tropical areas	26° - 50°	Thomas, 1994
Humid tropics	> 40°	Birot, 1960
Abadare ranges (Kenya)	> 20° > 35°	Ngecu and Ichangi, 1998 Davies, 1996
Northern and Southern Ethiopian highlands	20° - 45°	Ayalew, 1999
Northern Ethiopia	19° – 56°	Nyssen *et al*., 2002
Wondogenet (Ethiopia)	10°-20°	Temesgen *et al*.,2001
Western Uluguru (Tanzania)	28° - 44°	Rapp *et al.,* 1972
Southwest Rwanda	> 25°	Moeyersons, 2003
Western Uganda	> 26°	Doornkamp, 1971 (in Rapp *et al*., 1972)
Bududa	14°- 41°	Knapen *et al.,* 2003.

Table 1: Slope Gradient Thresholds for landslides in Eastern Africa (Knapen et al., 2005)

Because the Bududa District is predominantly rural, excavation and the undercutting of slopes occur during the construction of houses, footpaths, and the leveling of plots (Knapen et al., 2005). These activities create step-like formations along the slopes, which weaken lateral support. This creates vulnerabilities within this area because as discussed earlier the bedding planes of the substrata are parallel to the slope (Knapen et al., 2005). Figure 4 illustrates how excavation and human

development change the original shape of the slope and in turn weaken its stability and figure 5 provides images from the district.

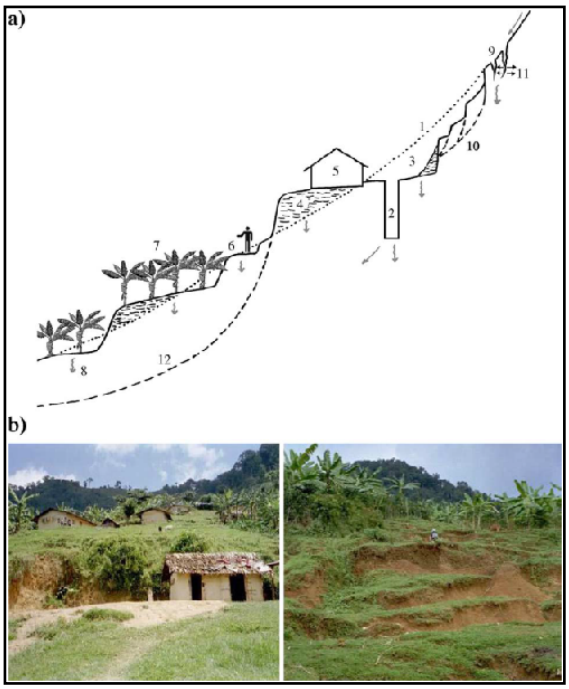

Figure 4: a) Illustration of human activities that change slope stability b) Images depicting these activities in the Bududa District (Knapen et al., 2005)

Figure 5: In 2007, two young girls in the district were killed while the house was buried because of poor slope stability, a result of construction of the house (NEMA, 2010)

Another larger landslide occurred in November 1997 in which 339,330 m^3 of slope material slid down destroying 97 houses and displacing around 700 people (Knapen et al., 2005). A study was performed to determine the impact that human excavation had on the landslide in light of the natural factors. White (1999) found that 105 houses and small agricultural plots with an average area of 50 m^2 outside the landslide area had excavation depths between 0.15 and 4.5 m with an average of 1.25 m. This allows runoff water to concentrate and strain to increase. Human activity proved to be a very influential factor in exacerbating vulnerable slopes.

Deforestation

The clearing of forested lands across Uganda has been occurring for decades and presents some significant problems to ecological systems. In the Bududa District, deforestations started in the 1930s and have continued at a high rate although spatial and temporal information is lacking (Hamilton, 1984). Frank Mugagga, a lecturer at Makerere University, performed a Land Use study on the Manafwa District, the district directly south of the Bududa District, in order to determine how land cover has changed from 1960-2006. He found that from 1995 to 2006 woodlands and forest cover were substantially reduced by 58% and 34% respectively and agricultural fields increased by 241% (Mugagga et al., 2012). In Figure 6, he mapped the changes over time.

Although this is not the district being studied, similar trends are being experienced in all Districts at the foot slopes of Mount Elgon. Therefore, these numbers are not unique to this district.

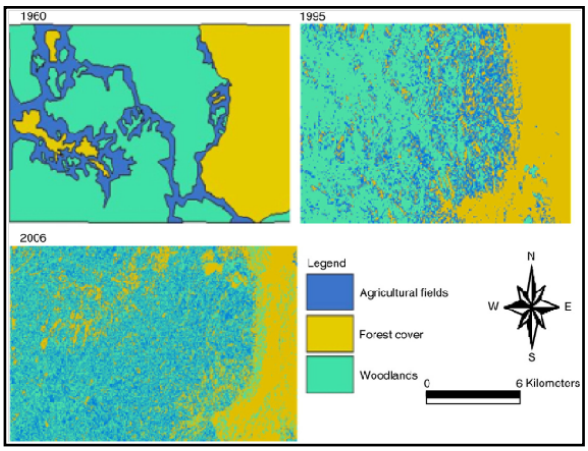

Figure 6: Changes in Land cover in the Manafwa District between 1960 and 2006 (Mugagga et al., 2012)

Moreover, deforestation becomes a function of population growth as noted by Knapen et al. (2005). As populations grow, they are forced to clear unsuitable steep slopes in order to cultivate them. Thus, the Bududa District's population growth contributes to higher rates of deforestation.

Deforestation is a preparatory factor for landslides because it contributes to decreasing slope stability. Deep roots from forest cover stabilize slopes by providing structure to a slope. Moreover, they can minimize the weakness of bedding planes by linking the soils of a slope. Thus, when this forest cover is reduced and replaced with shallow agriculture, the structure and support goes away. In the NEMA Report (2010) on the Bududa District, stability analysis showed that deforestation decreased the safety factor (a measure of slope stability) by 30% to 60% on slopes within the Bukalasi and Nusu ridge zone. Figure 7 displays the contrast in land cover on a slope within Bubita in which the thicker vegetation prevented landslides in 1997 while the bare, cultivated slopes experienced surficial landslides.

Figure 7: Contrast of slope land cover in Bubita, 1997 (NEMA, 2010)

Thus, deforestation can be considered one of the most significant preparatory factors in regards to landslides within the Bududa District along with regions across the East African Highlands (Knapen et al., 2005)

Triggering

Triggering factors are characterized as morphological causes that allow the land to exceed the perpendicular component of gravity. They are the final push whereas the preparatory factors and preconditions prime the land.

Seismic

Often landslides accompany other natural hazards, particularly earthquakes. This is because the additional shaking provides the additional force that weaker slopes need to break loose. Although the Bududa District sits along the East African Rift zone, it rarely experiences earthquake (Hollnack, 2001). Thus, seismicity cannot be attributed as a major triggering factor within this area as it can in other places around the world.

Erosion

Erosion, particularly at the base of unstable slopes can trigger landslides by weakening it to the point of failure. This can be natural in the form of streams or it can be

man made in the form of irrigation and drainage. Bududa does experience erosion along fast moving streams especially in Bulucheke and Nusu areas (NEMA, 2010). However, it is not seen as the most significant factor in triggering landslide events. Nevertheless, a way to prevent further erosion along riverbanks is to plant vegetation as a buffer as well as constructing retaining walls.

Precipitation

The Bududa District observes a bimodal rainfall pattern in which the wettest months are from March until October, and the dry season is from November until February. Figure 8 displays the rainfall distribution for the Mount Elgon region. Note the two peaks during May and August which both occur during the wet season. Kitutu (2010) found that rainfall is higher at the southern and western slopes (1500-2000 mm/year) compared to the eastern and northern slopes (1000-1500 mm /year). Further interviews with local farmers revealed that rainfall typically occurs in the afternoon hours with clear mornings (Kitutu, 2010).

Rainfall significantly contributes to mass movements through creating "hydrostatic pressure" and acting as lubricant once slides are in motion (Kitutu, 2010). Hydro static pressure is created as water stagnates within the predominantly clay soils. This added weight pushes slopes past a certain threshold, which overcomes the perpendicular component of the force of gravity. Although an exact threshold cannot be determined for the region, correlations exist between high rainfall months and concentration of landslide events over time.

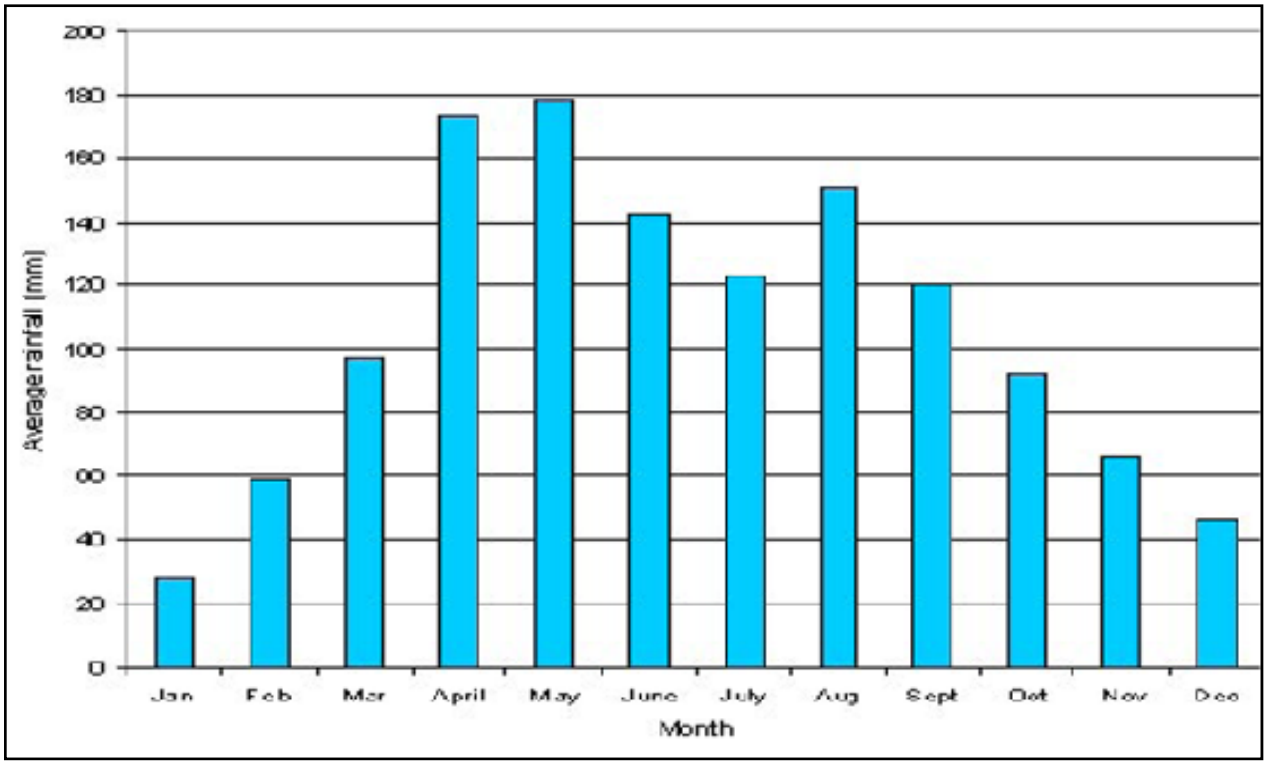

Figure 8: Rainfall distribution for the Mount Elgon Climatic Zone (Kitutu, 2010)

Knapen et al. (2005) plotted the amount of precipitation for 2002 and 2003 in conjunction with the number of landslides per month from 1997-2002. Figure 9 Displays the results which show a correlation between precipitation and landslides, particularly during the month of May

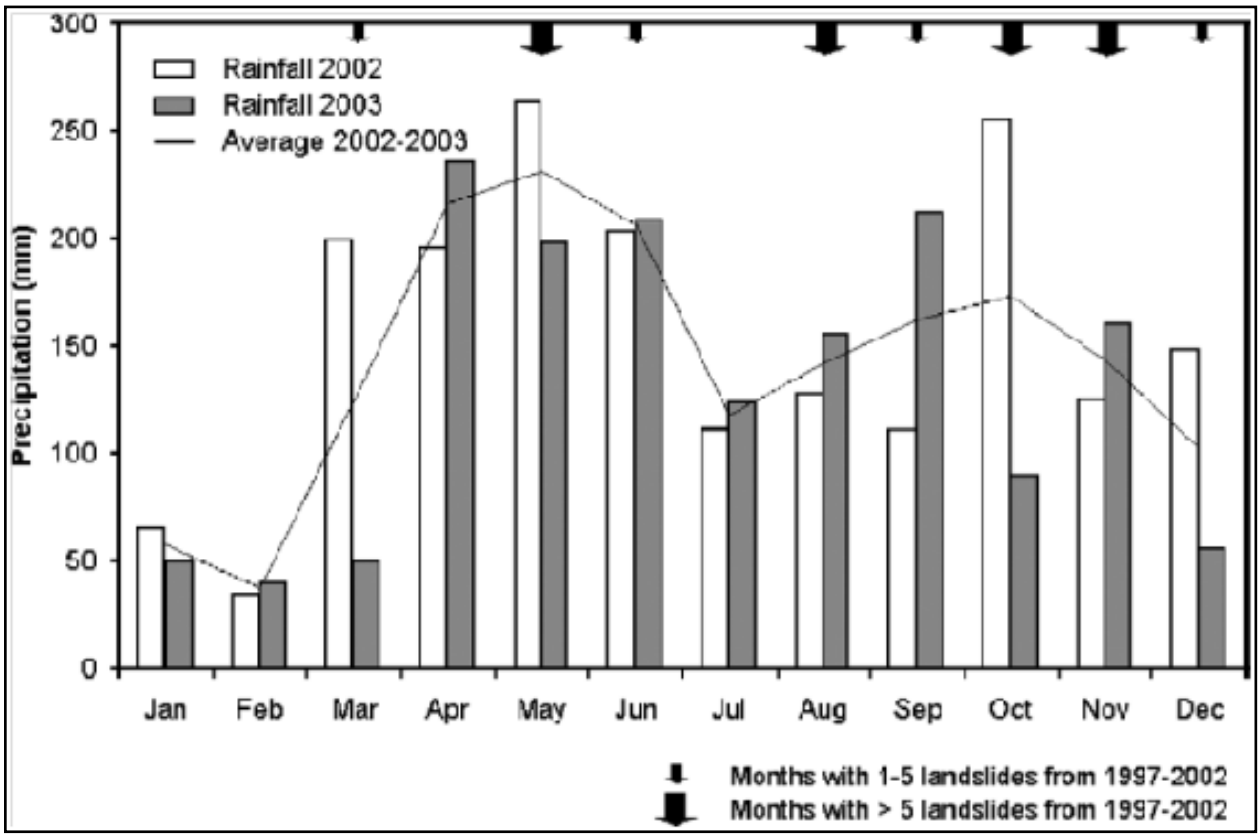

Figure 9: Monthly Rainfall within Bulucheke 2002-2003 (Knapen et al., 2005)

Landslide events most frequently take place in correlation within years a high rainfall, particularly at the end of the rainy season (Kitutu, 2010). The devastating Nametsi landslide in 2010 was preceded by continuous rainfall which increased the weight of the slope from runoff (NEMA, 2010). Precipitation consistently triggers large and small scale landslides within this District.

Overarching Model

With so many contributing factors, the question becomes which one is most influential and is it human related? Frank Mugagga, in an interview, discussed how all these factors are interrelated. He went on to further explain that the natural conditions exist but human activity obviously contributes to where and when landslides do occur. In a study he performed on characterizing the soils around Mount Elgon, Mugagga created a conceptual model depicting the interrelationship between internal and external factors that influence landslides (Figure 10).

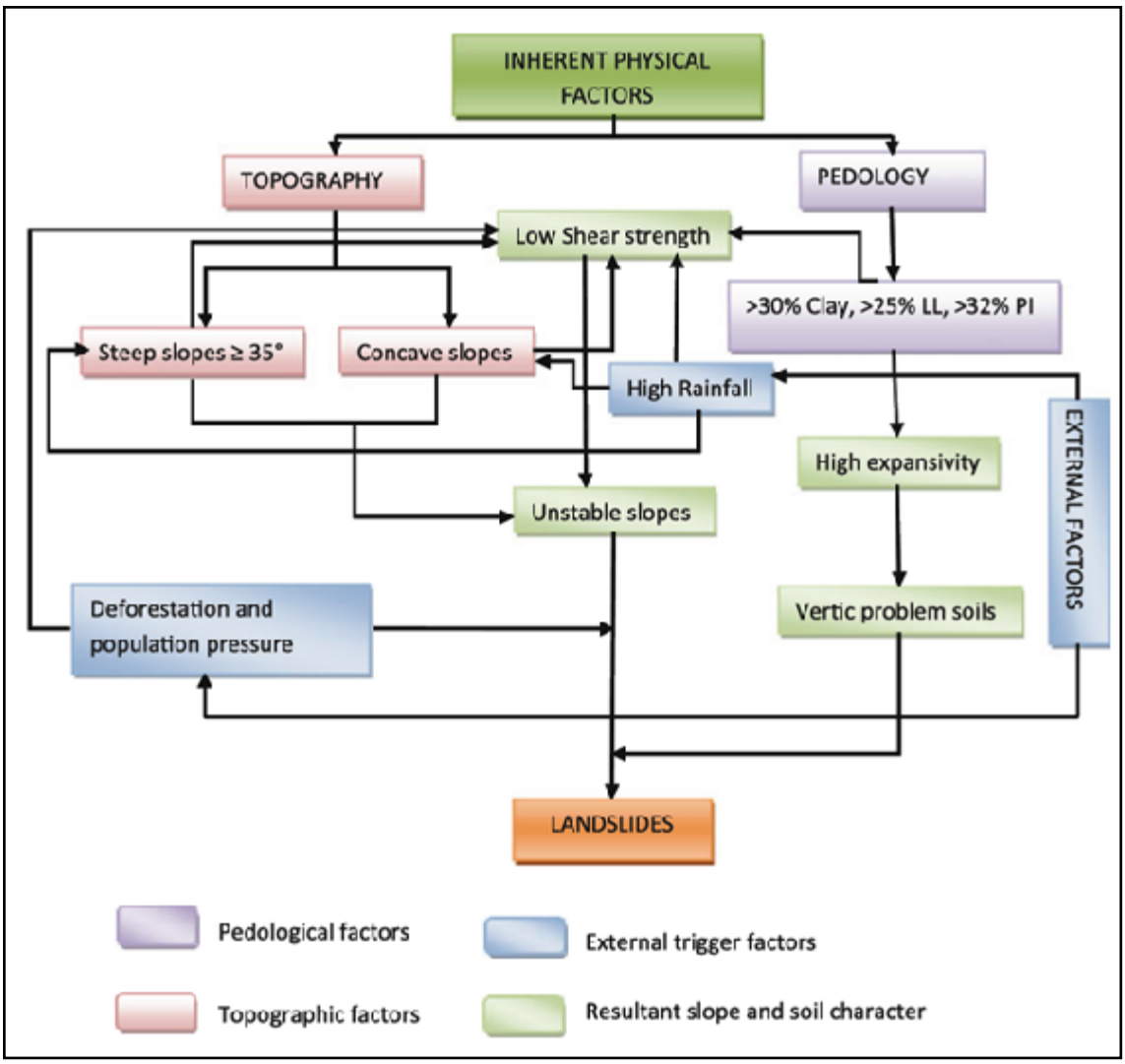

Figure 10: Conceptual Model depicting the internal and external causes for landslides (Mugagga et al., 2011)

His conclusions are that regions around Mount Elgon, including the Bududa District, have "'problem soils' where slope failure could occur even without any human intervention" (Mugagga et al., 2011). Yet, during the interview, Mugagga emphasized the significant impact that human activity has on exacerbating existing conditions within the Bududa District. The soils are very susceptible in composition and formation. High rates of precipitation trigger the landslides. Human activities deprive the slopes of structure and support. Thus, risk inherently exist and is further increased with human activities and development.

Resilience

Resiliency can be defined differently with many definitions and models. Moreover, scaling this resiliency from household, local, regional, and national can be a difficult when trying to isolate an area. However, this analysis adopts Fran H. Norris's framework for community resilience as four networked adaptive capacities: economic development, social

capital, community competence, and information/communication systems. After establishing the existing environment vulnerability to landslides, this paper aims to assess the communities within the Bududa District on their ability to adapt after these events occur. This brief assessment will be qualitative in nature as it will draw from existing studies, statistics, and personal interviews. Moreover, Norris lays out five steps in which communities can improve their resilience. These will be applied to the Bududa District and assessed in terms of being achievable, realistic, or applicable.

What is resilience?

In light of the many definitions, the analysis will use Norris's (2007) definition, which states that community resilience is "a process linking a set of networked adaptive capacities to a positive trajectory of functioning and adaptation in constituent populations after a disturbance." Thus, the focus becomes the ability to adapt rather than the adaptation itself. This will be assessed by looking at economic development, social capital, community competence, and information / communication systems. These four capacities, according to Norris, work together to determine a community's ability to adapt. Note these are labeled as adaptive capacities rather than resources, because they are evaluated on the type and the dynamic attributes of the type of resource, namely robustness, redundancy, and rapidity. Robustness refers to a resources ability to withstand degradation when stressed (Norris, 2007). Redundancy is the ability to mitigate degradation by having diversity in options. Lastly, rapidity is the ability to mobilize and respond under stress. Further explanation in regards to these adaptive capacities will be done following the scaling of resiliency for the purposes of this study.

Scale is very important when assessing community resilience. Different areas have different size communities. For example, a community within Chicago might consist of thousands of people while a community in Papua New Guinea might consist of twenty. For the Bududa District, community resilience will be viewed through the village level. Assuming the average village consists of 50 households, a community would be 220 people (UBOS, 2013). However, larger scale institutions along with household vulnerabilities will be considered.

Economic development can be broken down into resource volume, diversity of resources, and the distribution of resources. Naturally, having a larger resource base to draw from that is evenly distributed and diverse is more capable of adapting. More resources like land, raw materials, physical capital, accessible housing, health services, schools and employment opportunities create the basis for a resilient community (Norris, 2007). At a more basic level, the more money a person has, the more able he or she is to overcome adversity in regards to basic needs like food, water, and shelter. Diversity of resources lessens the chances that the whole of one's resources will be degraded in the event on a disaster. For example, diversity in subsistence farming prevents starvation in case a disease wipes out certain crops. Lastly, even distribution of resources increases the ability to adapt by promoting self-reliance. Everyone becomes equally resilient, ridding communities of weak links created by poorer components.

Social capital can be assessed by evaluating network structures and linkages, social support, and community bonds. Network structures and linkages, according to Goodman et al. (1998) are characterized by reciprocal links, overlapping networks, ability to form new associations, and a collective decision making process. Moreover, these can be viewed as institutions at the community level that promote support between households. The more involved these institutions are with the community, the more resilient the community is in responding to disasters. Social support, according to Norris (2007), refers to social interactions between households that build confidence that assistance will be provided in times of need. Stronger relationships between community members build the capacity for members of communities to help one another in times of crisis. Lastly, a community bond refers to a household's attachment to the community itself. It is strongly linked to place attachment in which people feel a sense of commitment towards their neighbors and more importantly, their community. Although place attachment has been found to impair some recovery in regards to displacement, community ties strengthen the desire to rebuild (Norris, 2007).

Information/communication systems can be divided into infrastructure for informing the public and means of communication. Information during disasters is a powerful tool in both the response and recovery stages. However, Longstaff (2005) states that it is only a benefit if it is "correct and correctly transmitted." Thus, infra-structure that can provide reliable, trustworthy and accurate information throughout a community drastically increases resilience. Communication and the passing on of narratives refer to a community's ability to pass on experience with shared meaning and purpose (Norris, 2007). This is the 'lessons learned' component of communal knowledge, which allows all members of the community benefit and adapt for future events. Moreover, this can be seen through the education of a community.

Lastly, community competence refers to a community's ability to make a decision and the trust that the community has in that decision. Effective decision-making is marked by efficient collaborative action in terms of risk, response and recovery (Norris, 2007). This can be viewed through disagreement during the decision making process. Trust in the community decision can be viewed through the community's ability to carry out the decision.

These four capacities and their relationship can be observed in Figure 11, which is a conceptual model for their interaction.

How can a community increase their resilience?

Norris lays out five steps to increasing community resilience, although he states that these are by no means all-encompassing nor are they limiting in that a community can start and stop wherever they so choose. These five steps are 1. Developing economic resources, reducing risk and resource inequities, and addressing areas of greatest social vulnerability 2. Engage local people in every step of the mitigation process 3. Strengthen organizational networks for rapid mobilization during emergencies 4. The boosting and protection of naturally occurring social supports in the long-term must occur 5. Communities must plan for the unknown (Norris 2007). The United Nations Office for Disaster Risk Reduction

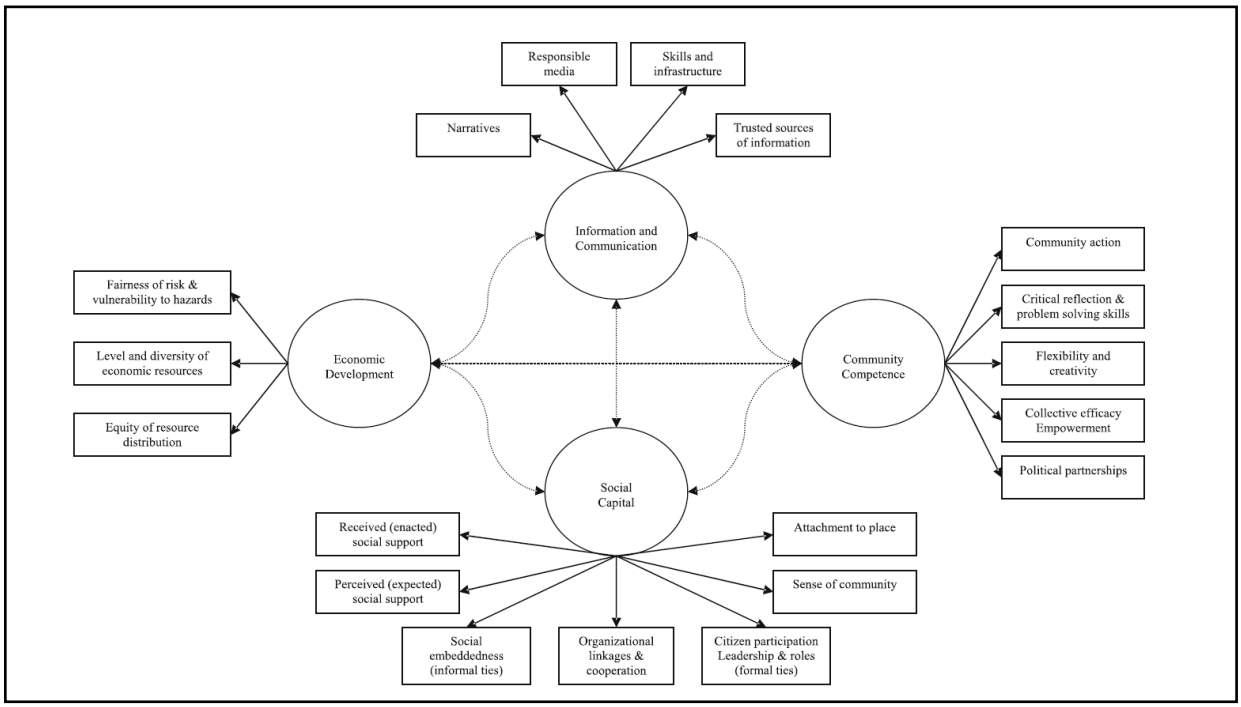

Figure 11: Community Resilience as a set of Networked Adaptive Capacities (Norris, 2007)

published a proposal to policymakers on making more resilient cities. In it they provide ten essentials that increase resilience ranging from education to land use planning principles (Clos, 2013). Other areas of emphasis include developing infrastructure, early warning systems, and risk assessments. However, some of these seem more focused on urban environments. Thus, the question becomes how communities, particularly in a rural environment do, do this in regards to landslides? Philip W. K. Chung, head of Public Education and Community Advisory Service Unit in the Hong Kong SAR Government, provided four ways to enhance community resilience specifically to landslide hazards. They are to build proactive public communication and education, comprehensive information service, early warning, and effective emergency response (Chung, 2010). Hong Kong, an area vulnerable to landslides, provides excellent opportunity to put these enhancements into practice. Public education teaches land owners how to manage their slopes as well as promoting understanding on what causes landslides (Chung, 2010). Early warning may take the form of hazard mapping, slope monitoring with rainfall gauges and geophones, and the ability to warn those at risk to a hazard. Comprehensive information service means the ability to provide required information, knowledge or expertise in slope improvement or maintenance works through available resources to the public (Chung, 2010). Lastly, effective emergency response refers to the ability to provide advice for imminent landslides and provide assistance during the rescue and recovery as soon as possible. Katie Oven, researcher at Durham University, found that in Nepal some of the best policies that landslide prone communities can adopt are avoiding the hazard, large-scale education, slope monitoring, and involving

the local level in everything in order to promote self-reliance (Oven, 2009). All these methods are valid when building resilient communities.

In addition to resilience, the value of reducing vulnerability cannot be ignored. Vulnerability is the degree by which a system is likely to experience harm due to exposure to a hazard (Turner, et al. 2003). Thus, vulnerability and resilience are tightly linked. For example, if a boxer gets knocked down in a boxing match, then resilience is his ability to get of quickly. If a boxer gets caught with his eyes closed and gets knocked down, then that is a large vulnerability. It then stands to reason, that if a community can decrease the impact of a hazard by decreasing its vulnerability, then the community will display increased resilience by recovering faster. In fact, vulnerability and resilience overlap. Vulnerability can be divided into three areas: social, economic, and physical (Juventine, 2012). Social vulnerabilities can take the form of social capital, individual characteristics of people, and many more social considerations. Economic vulner-abilities similarly relate to sources of income, diversity of resources, and income distribution. Lastly, physical vulnerabilities are derived from the natural environment and human interactions with it (Juventine, 2012). A few strategies to decrease these vulnerabilities include creating preven-tative strategies, impact minimizing strategies, building up stores, diversifying income sources, and developing social support networks (Cutter et al, 2003). An acknowledgement to decreasing vulnerability will also contribute to increasing community resilience.

How can resilience be improved in the Bududa District?

As previously discussed, the Bududa District will be briefly assessed using Norris's resiliency framework. Then, the methods of increasing resiliency will be applied in light of the assessment to determine if they are reasonable or unattainable at this point in time.

Economic Development

Economic development within the Bududa District appears to be largely homogenous throughout the region in regards to the source of income. According to the 2002 Census taken by the Ugandan Bureau of Statistics (2013), 89% of the District was classified as subsistence agricultural workers while 5.7% qualified as skilled, 3.8% as professionals and 1.4% as elementary workers. Similarly, 95.5% of communities registered their economic activity as relating to the farming and trading of agricultural produce (UBOS, 2013). Overall, the 100% of the district was classified as rural. Compared with the national trends, the Bududa District is 18.3% higher in the category of subsistence agricultural workers (UBOS, 2013). In regards to household income, Juventine (2012) performed a survey across 261 household heads throughout the district. He found that households find other means of income like brewing and charcoal burning to gain more income. Yet, these are still tied to agriculture. He also determined that the 69.57% of those surveyed earned between 5,000 – 300,000 (UGX) per year (an equivalent of $117.64) while 21.92% earned more than 500,000 (UGX) (an equivalent to $196.07) (Juventine, 2012). The average Ugandan GDP per capita according to World Bank (2012) is $551. Even the high range for those surveyed is drastically below the national average GDP per capita. Lastly, poverty can come in many different forms

to include being deprived of assets, being physically weak, being isolated, being vulnerable, and being powerless (BDLG, 2011). According to the Bududa District Local Government, communities in this district experience every single one of these types of poverty. They also found that this district had an average poverty incidence of 33% in 2007 (BDLG, 2011).

Overall, communities within the Bududa District display severe economic vulnerability because they are highly tied to the land. Without diverse sources of income, disasters can easily disrupt livelihoods to leave households and communities food insecure.

Moreover, the size of economic resources earned on a yearly basis proves to be significantly lower than the national average. Lastly, even though wealth is low across the district, there is still a high incidence of poverty, which drastically decreases resilience against changes in a system. The Bududa District Government made a good point in tying a population density of 952 people per square kilometer to the level of income by saying a single "household has no land or has only land that is barely enough for subsistence" (BDLG, 2011). Thus, there is not much room for economic growth in regards to large-scale agriculture. One of the major challenges facing this district, like the rest of the nation, is attaining the resources to implement new policies and changes (Bamutaze, 2014). During an interview with Dr. Bamutaze, a researcher and professor at Makerere Unversity, he expressed an informal plan to restructure the Bududa District's economy by forming urban centers on less vulnerable lower slopes in order to protect lives and potentially diversify the economic situation. It will incorporate more business and service-based occupations. Yet, it will never be a complete 50/50 distribution. He explained that the government understands the high economic vulnerability that the District currently experiences which is fueling the desire to diversify. Nevertheless, it will be a slow transition. The economic situation is one facet of resiliency within the Bududa District but it will also inform the district's ability to implement new policies or develop infrastructure.

Social Capital

Social capital, in regards to social institutions and social support, appears to have moderate strength within the Bududa District. After conducting an interview with MG Oketta (2014), leader for the Ugandan Directorate of Disaster Preparedness, it became clear that there are district level institutions designed to respond to disasters. These are called District Disaster Management Committees. When they become overwhelmed, the national government gets involved. In addition to governmental groups, MG Oketta mentioned that Red Cross, World Bank, and USAID were also active at the district level when recovery was needed. Other organizations include the Partnership Overseas Network Trust, the Mbale Coalition against Poverty, and the Shunya Yetana Community Based Organization (Jenkins et al., 2013). Dr. Bamutaze (2014) indicated that both groups were highly reactive towards disasters rather than preventative. A study in 2013 found that the DDMC "had not convened since the end of relief operations" for the 2010 Nametsi landslide (Jenkins et al., 2013). It comes down to a matter of funding. The lack of funding leads to underdevelopment in regards to management of disaster prevention. He

also described how communities are able to create response teams in by assigning responsibilities to members if a disaster occurs. This is the very local level in which people respond to every day hazards.

Juventine (2012) also delved into the topic of social support by asking how people were able to respond to natural disasters. The strongest forms of support appeared to reside in the surrounding community. 59.77 % of households managed after sudden shocks through support from friends while 49.81% managed from support from family (Juventine, 2012). Community organizations and NGO's helped 26.05% of respondents, which also indicates that they are not as helpful as they could be (Juventine, 2012). These questions do not appear to be mutually exclusive so some overlap may exist in regards to where these households received help. It could have been a combination of the organizations present. Yet, social support from the surrounding community in regards to neighbors and family appears to be the strongest form of social capital. This makes sense because isolated communities such as those found within the Bududa District often have no one else to lean on except those within the community.

Lastly, attachment to community and place appear to be strong for communities within the Bududa District. MG Oketta discussed a resettlement program in which comm-unities affected by the 2010 Nametsi Landslide were moved to portions of eastern Uganda. Although he confessed that it was a huge success, Dr. Bamutaze and Mr. Mugagga explained that many people migrated back to the Bududa District only to settle on even more vulnerable slopes. It failed largely because people had no familial ties or ties to the land. The 2002 census determined that 99.4% of respondents have resided in the same place since birth (UBOS, 2013). This suggests that these people have very strong ties to the land and to their communities. A strong sense of place can be good in response to helping others in the community. It can also hinder prevention strategies and small-scale resettlement programs, particularly the one described by Dr. Bamutaze. Although social institutions may be weak, social support appears to be the main coping mechanism for small-scale and long term response to landslides.

Community Competence

Community competence, although difficult to assess, can be seen in how communities make decisions and the trust they put in those decisions. The interview with MG Oketta along with Dr. Bamutaze showed how communal acceptance of governmental policies was low particularly in command and control strategies like resettlement and restr-ictions. Additionally, Mr. Mugagga explained how infringement into the national park has continued over the past few decades as communities ignore national park boundaries. Yet, MG Oketta expressed how when he involved local leaders in the policy process, then the communities were more receptive towards change. He focused on regulation policies that limit where people can develop. Ultimately, the best way to win over the hearts and minds of the locals is to involve the local leaders. They are more willing to accept decisions when their own counsels are educated and involved in the decision making process. Another study found that after the relocation program occurred after the 2010 Nametsi Landslide, "survivor participation in

decision making was weak/absent" and village council planners were not involved in operations (Jenkins et al., 2013) It is difficult to have competence in decision making when local communities are not involved. Yet, examples of community involvement are also available. For example, the national park service involves the local governments with the parks. Essentially, some of the park's revenue goes towards local development projects in terms of infrastructure and basic needs in order to foster preservation by the local communities. Mr. Mugagga stated that this method was successful in some parts and not successful in others. Nevertheless, higher community competence can be linked with higher community involvement.

Information/Communication Systems

Information/communication systems can be broken down into two categories: how readily available information is and how trustworthy it is. The former is more easily measured than the latter. The 2002 Census found that 62.1% of those surveyed acquired information via word of mouth while 36.8% used a radio. Keep in mind that the national average is nearly 50/50 split between the two sources of information. Yet, it is still about 14% higher than the national average. Furthermore, 99.4% do not own a television set, 99.6% do not own a mobile phone and 100% do not own a fixed phone (UBOS, 2013). Another hindrance to communication is the fact that only 12.6% of communities have all weather road access while 39.5% have seasonal access and 47.9% have none at all (USOS, 2013). This compliments the fact that only 0.2% of those surveyed owned a motor vehicle (UBOS, 2013). Thus, the people within the Bududa District are isolated in terms of communication and road access. Juventine (2012) found similar results a decade after the census was performed. Of the 261 households surveyed, he found that the main sources of information were word of mouth and local council meetings yet it was only marginal (Juventine, 2012). Television, radio, posters, internets and newspapers were practically nonexistent (Juventine, 2012). Other studies describe the current state of civil infrastructure as "limited with a paucity of good roads and healthcare facilities" (Jenkins et al., 2013). These findings further the claim that the majority of the Bududa District is isolated. Moreover, they display that communication infrastructure has been slow to change as well. This presents challenges for the implementation of early warning systems, hazard mapping, and even large scale education because of the isolation from road networks. It does not mean it is unfeasible, just more difficult.

Increasing Resilience

After assessing the current state of resilience for communities within the Bududa District, it becomes clear that the major challenges are the amount of resources available (i.e. funding, markets, and goods) and current infrastructure to include access and communication. Thus, the implementation of new projects and policies should be viewed in conjunction with these major challenges. Moreover, when proposing these projects, governmental resource allocation or lack thereof should also play a role in the planning process. Yet, programs should dually "build upon local capacity" and "avoid undermining people's own coping strategies" (Jenkins et al., 2013). The most feasible ways to improve community resilience in the short term would be to employ a large-scale education program,

create local response organizations, and disaster risk mapping. Additionally, reforestation remains the clear path towards decreasing vulnerability to landslides. Long-term programs to improve resilience should include developed infrastructure, resettlement of residences, economic diversification, and slope monitoring.

A large-scale education program is the most feasible way to control the anthropologic factors that are influencing landslides. Currently, farmers "cultivate every inch of land they can obtain and the district has no environment officer" (Jenkins et al., 2013). Educating villagers on what factors contribute to landslides, how to manage slopes, and where to build residences can decrease the impacts that landslides have on communities. Because an early warning system is not feasible in the short term due to infrastructure limitations, educating on the triggering factors for landslides such as high amounts of precipitation may be the best way to help villagers anticipate landslides. This is feasible because it can be done at the community level. Members of the National Environmental Management Authority who have written multiple reports regarding landslides in this district could conduct classes with household heads from each village, particularly those in identifiably vulnerable areas. These would have to be a robust set of individuals as many communities are inaccessible by road. Nevertheless, government officials already invested in the region could properly disseminate the education program.

Local response organizations would be necessary in each village to be able to respond to small-scale landslides that do not warrant the attention of the DDMC or are inaccessible. This can also take place during the education program. After interviewing Dr. Bamutaze, informal response teams do exist at the local level and respond when called upon. This policy would formalize existing institutions in order to possibly better resource and better communicate with them. These response teams could also be mitigation teams helping to disseminate information throughout the village seeing as word of mouth is the dominating form of communication. In fact the DDMC recognizes "the need of local engagement and envisaged co-opting a network of trained [village council planners] to provide a lowest tier" (Jenkins et al., 2013). Some claim that the best community based organizations grow from the bottom up, which necessitates the engagement of the local communities.

Disaster mapping of vulnerable slopes can also occur during the process of going from village to village. Evaluating slopes based upon soil composition, slope angle, vegetation cover, and number of people present will inform villagers of the risk associated with vulnerable slopes. A comprehensive risk mapping may occur in the long term. However, in the short term a more informal assessment is most feasible. Thus, every slope will not necessarily be assessed but the villagers can be equipped with the knowledge to assess slopes themselves. This process has already occurred in some capacities. Dr. Festus Bagoora, an expert from the Department of Geography at Makerere University, submitted a study through NEMA warning of areas where the risk of landslides is high (Jenkins et al., 2013). However, no significant action was taken in light of this study. Some sort of incentive must accompany an assessment as well.

Lastly, reforestation appears to be the most widely accepted form of mitigation as MG Oketta's, Mr. Mugagga, and Dr. Bamutaze's interviews proved. Additionally, Juventine (2012) showed many villagers' willingness to conduct reforestation efforts in conjunction with governmental aid. Furthermore, MG Oketta described education programs that are currently underway which teach villager's the types of trees that are best for stabilizing slopes and river banks. Nevertheless, reforestation is not necessarily a cure-all as displayed by Mr. Mugagga's analysis. Landslides will occur regardless of anthropologic influences. Thus, reforestation should be conducted parallel to the other programs mentioned.

The long-term plan, similar to what Dr. Bamutaze described, should resettle residences to less vulnerable areas while concentrating agriculture in the moderate risk zones. This does not necessarily reduce the damages but rather aims at reducing the risk to lives. Accompanying these more concentrated residential areas would be more business and service based jobs to diversify the economic situation. Additionally, it would be easier to develop and provide infrastructure during this resettlement stage. Lastly, those slopes being used for agriculture could be monitored based upon stability and soil saturation to predict the potential shear stress on the hillside. These are clearly long-term goals as resources are scarce and development has proved to be slow within the Bududa District.

Suggestions for Further Study

Further studies should occur in the next few years providing newer statistics. A limitation of this study was that the majority of statistics were from a 2002 census. However, the incorporation of more modern surveys to validate the census data was used. In 2014, the Ugandan Bureau of Statistics is taking another census. In light of new data, another assessment should be done. Other studies should involve a GIS based project to map the entire district in order to evaluate high-risk slopes in conjunction with development patterns. An evaluation of the effectiveness of reforestation would also be helpful.

Conclusion

Landslides within the Bududa District have proven to be a natural occurrence due to the types of soils, the slope angles, and the amounts of precipitation throughout the year. Yet, human activity exacerbates these vulnerabilities by increasing the likelihood and the intensity of landslides through excavation and deforestation. In regards to resilience, the Bududa District is economically vulnerable due to highly agrarian communities in which their livelihoods are directly threatened by landslides. However, diversifying this region economically may be a slow process. Yet, there are some long term strategies that are being developed to incorporate industrial and service based activities. Past landslides have shown societal support is effective in the recovery after the event but social institutions are lacking. Government and NGO involvement has focused more on recovery rather than prevention. Community Competence is lacking due to being left out during the Nametsi Landslide. A large issue which faces community through district level decision making is the lack of funding. This, also, is a work in progress. In regards to information and communication, development of infrastructure like roads and electricity would increase

community's ability to respond to landslides. Lastly, one of the most reasonable means of decreasing vulnerability is reforestation programs at the local level. It is supported by the government and accepted by the local communities as a reasonable short-term step towards mitigating risk to landslides. Nevertheless, landslides continue to be problematic even for developed countries. It is important to emphasize mitigation but the development of resilience proves to be invaluable for communities living with persistent hazards like landslides.

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Environmental Security in the Lake Victoria area of Uganda

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"Currently, sanitation facilities are not adequate in the urban or rural areas. Only 34% of the urban population has access to improved sanitation facilities. This is why pollution is such an issue that can cause vulnerability. There are no mechanisms in place to rid the system of pollution."

When conducting field work and traveling in Uganda, I began to get a sense that Ugandans from the farmer to those in international Non-Government Organization are in tune with the environment they live in. Climate variability and a lack of sanitation are not abstract concepts. These concepts are part of daily lives and decision making. In this paper, I use Lake Victoria as a case study to highlight the role of the environment in overall wellbeing and security.

Case Study: Lake Victoria

Lake Victoria is a large lake situated in between two Rift valleys. It is bordered by the countries of Uganda, Kenya and Tanzania. Situated on a high plateau and punctuated by rivers and lakes, the area surrounding Lake Victoria has the advantage of a bi-annual rainy season based on its latitude, and a moderate temperature range because of the plateau's altitude, allowing much of their farming to be rain fed (CIA World Fact Book, 2013). The catchment basin for Lake Victoria expands well beyond the three border countries. As seen in Figure 1, the catchment basin stretches to Rwanda and Burundi as well. From Lake Victoria, the White Nile flows north where it joins the Blue Nile and continues through Egypt to the Mediterranean. Lake Victoria's catchment basin brings pollution with the water it collects. Much of the pollution stems from soil erosion due to poor farming techniques and runoff from animal waste (Cole, 2007). Heavy metals from petroleum products add to these agriculture and livestock pollutants (Ogwok, 2009). Rainfall in the area contributes to pollution by washing pollutants from ground sources into the water. Kampala, the capitol city of Uganda, is situated on the northern shoreline of the lake. This city, adjacent to shoreline wetlands, is expanding rapidly. Much of Kampala's informal peri-urban settlements are in the wetland regions in the outskirts of the city (Vermeiren, 2012). Kampala serves as the connection point from the lake into the interior of Uganda and is a key hub of goods and transportation.

Lake Victoria and the Environment

The people of the Lake Victoria region are especially vulnerable to environmental impacts. The relationship the people have with their environment is strong, because they rely on Lake Victoria for not only services such as drinking water, but also

because for a substantial portion of the population their income comes from activities on or near the lake (Vermeiren, 2012).

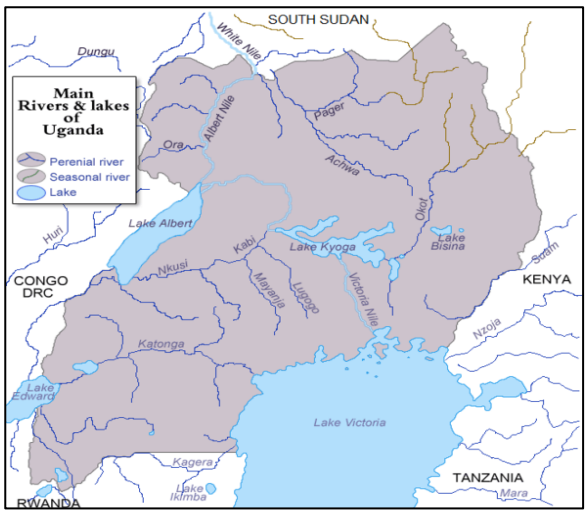

Figure1: Main Rivers and Lakes of Uganda (Wikimedia commons)

The population of Ugandans living in informal settlements of Kampala is deeply affected by impacts on environmental security. Currently, there are 1.535 million people living in Kampala, many in informal settlements. Many do not have access to clean water or sanitation and supplement their income with agriculture in polluted land. Their relationship with the environment means they will be greatly affected by its demise.

This research is intended to be a comprehensive analysis of environmental elements of Lake Victoria, which affect its inhabitants. The critical area in these interactions exists along the shoreline of the Lake. Here, the exchange of pollution from people to the Lake and from the Lake back to the people amplifies issues that may not be seen farther inland. This environmental security framework analyzes the destabilizing effects of pollution in three distinct groups: Culture, Environment and Governance. By examining these three groups, negative outcomes resulting from widespread pollution become apparent.

Background of the Issue

Uganda's current borders are the creation of European colonialism similar to many African nations. Prior to colonialism, several kingdoms ruled Uganda. Three large monarchs were incorporated into the Protectorate of Uganda, which was administered by the British (Cole, 2007). During colonial rule, Ugandan land was divided up between the Buganda king, smaller tribal rulers and the colonial power (Deininger & Ali, 2008). Beyond the king and noble landowners, there was no real ownership of land. The cultivators who lived on the land had to share their land rights with the colonial designated landowners (Deininger, 2008). After colonialism, the next influential political leader was Idi Amin. This president for life made some reform in the country, but was a harsh dictator (Deininger & Ali, 2008). The current president Yoweri Museveni subsequently replaced Idi Amin. In the modern era, Uganda has faced a myriad of problems including water issues. Population pressures cause the limited existing infrastructure to be overburdened and cease to function properly. Aging infrastructure in Uganda is resulting in cracked and leaking pipes. Once a pipe is cracked, it can begin to draw in moisture and pollutants from the surrounding ground and water table. In rural areas, water is collected from bore holes or roof tanks which can run dry during dry seasons (BakamaNume, 2010). All water issues ultimately relate back to the watershed area, which feeds the lakes and rivers of Uganda. Appromately 20% of the country is covered by lakes and rivers at

some point in the year, it is reasonable to assume that it is not the amount of water that is an issue, but access to and quality of water (BakamaNume 2010). Water access and quality is an issue everywhere in Uganda, but in Kampala, the problem is amplified by the large, dense population and aging infrastructure.

Rapid urbanization is becoming a major issue in Uganda and the infrastructure is not there to meet the rising demand.

Ideally, the country should be able to provide services to those migrants moving into the city, but in the current stage of development Uganda will be overwhelmed by battling the urban increase of 5.74% a year (CIA World Fact Book, 2013). Transparency International ranks Uganda 130 out of 176 states on the corruption scale and ranks it in the twenty-first percentile of all states, meaning that Uganda is more corrupt than nearly 80% of all countries. The country earned a ranking of 29 on a scale of zero to one hundred where zero is highly corrupt (Transparency International, 2012). Currently, sanitation facilities are not adequate in the urban or rural areas. Only 34% of the urban population has access to improved sanitation facilities. This is why pollution is such an issue and is causing vulnerability. There are no mechanisms in place to rid the system of pollution.

Kampala's Cultural, Environmental and Government Relationship with Lake Victoria

Lake Victoria plays a critical role in Uganda's water security, especially in the capitol of Kampala. About 1.5 million people are involved in the fish market, and fish account for 50% of the animal protein consumed by Ugandans (BukamaNume 2010). Water quality and access also influence development, because when water access is poor, people are not able to focus on improving their lives if they are relegated to walking long distance to clean water sources. Many Ugandan villagers find themselves walking over a mile to get water on a daily basis (BukamaNume 2010). Water quality is important because of the prevalence of water-borne pathogens.

In interviews conducted during the summer of 2013, local experts made the importance of the Lake to Kampala abundantly clear. A council of Geography professors at Makerere University, the leading university in Uganda, provide insight on the issue. The head of the Geography Department commented on the method of drawing water from Lake Victoria. The water is drawn from the lake through an intake pipe and as the lake becomes more polluted, the government is forced to move the intake location farther and deeper into the lake. Also, as many as 95% of the government protected springs in Kampala are contaminated (Interviews, 2013). This alone makes the Lake very important to the future viability of Kampala. Interviews conducted at the National Environmental Management Agency also revealed that they, as a government institution, believe that two of the greatest threats to Kampala's development are the encroachment of informal settlements on wetlands and the pollution of Lake Victoria (Interviews, 2013). The costs of pollution of the water in the area alone make this issue of vital importance to the inhabitants of the community.

Cultural, Environmental and Governmental Processes of Lake Pollution

History has shown that environmental stress will lead to destabilization (Krakowka et al., 2012). This issue is of pressing importance because of population characteristics surrounding Lake Victoria as well as the threatened natural eco-system. Once the natural ecosystem is disrupted it will take a much greater effort to regain the lost green space. Also, Lake Victoria is the home of many people whose livelihoods are tied to the lake, such as those who rely on Lake Victoria for drinking water or employment in the fishing industry (Myodi, 2011).

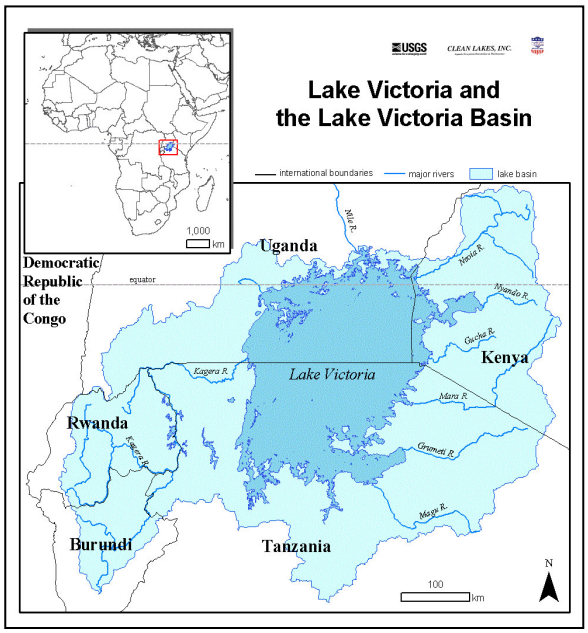

Figure 2: Catchment basin of Lake Victoria (USGS)

When the Lake becomes polluted, issues begin to emerge such as dehydration. Dehydration due to diarrhea is one of the leading causes of death in children less than five years of age (MALIK, 2012). Heavy metal pollution in Lake Victoria is one of the most worrisome pollutants. The lake has a very large catchment basin (Figure 2) and any pollution that occurs in this basin has the potential to concentrate in the main body of Lake Victoria. In order to prevent the pollution, all of the sources within the basin must be analyzed. The catchment basin is what brings life and vitality to Lake Victoria, but it also brings the pollutants.

Local experts expressed a deep concern about the Lake as a destabilizing process. Professors at Makerere University commented on the negative effect on health that groundwater contamination has as well as the issue of drawing from this contaminated source for drinking. An interview at the Danish Embassy in Kampala with Water & Sanitation Sector Development Partners revealed that many members of this international working group were concerned with the infrastructure of the water system being contaminated as well as the issue of general water pollution (Interviews, 2013). Members of the Joint Effort to Save the Environment (JESE) emphasized the effect water quality had on health, especially with the HIV/AIDS affected populations. When there is a lack of safe water, these patients are extremely susceptible to opportunistic diseases found in contaminated water. Desperate communities will compete for good water sources or steal water from the government installed school systems (Interviews, 2013).

The correlation between environmental pollution and destabilization is a real threat to areas such as Kampala where people's livelihood depend so greatly on the environment. There are many areas where water can cause a disruption in this interaction between people and their environment and make lives more vulnerable.

Application of an Environmental Security Framework to Lake Victoria

The relationship that humans have with their environment is a two way street. Humans pollute or rehabilitate the environment and the environment will reciprocate in kind. As the world develops and more stress is put on the environment, resolving this issue becomes more complex. Pollution occurs on several different scales, from the international to local.

Increasingly, however, the difficulty of mitigating complex environmental pert-urbations - for example, loss of biodiversity and habitat; stratospheric ozone depletion; degradation of water, soil and atmospheric resources and sinks; and global climate change-has made the need to integrate environmental dimensions into existing legal systems more obvious. (Allenby, 2000).

The key to human-environmental inter-action is to find a balance that facilitates both the needs of society and allows the environment to successfully function. To protect this balance, legal systems must be enforced in order to maintain envir-onmental security. Analyzing the interaction between humans and the environment they inhabit is of vital importance because there is a correlation between then quality of the environment and the quality of life of its inhabitants (Turner et al., 2003). In order to prove that there is causation behind this correlation, frameworks of analyzing the environment and its impact are created. These frameworks seek to reveal what effects that the environment has on those living within it as well as predict what can happen in the future. Ultimately, these environmental security frameworks fun-ction to reveal how vulnerable a society is. Vulnerability is the level of resistance that can be put up against outside stresses, whether environmental, economic or social. The model used in a quantitative, objective study of environmental security is best suited for many geographical studies. For this study, the complex interaction cultural factors play in addition to the desire to view risk and results also lends itself to a more structural framework. Ideally, this study will reflect a mixture of both objectivism and constructivism, which is applying evidence to a model without bias (Cardona).

In Africa, frameworks that have an end result are applied in order to see real world historical examples proving or disproving frameworks. For the extent of this study, the security must be thought of as not only as political threats, but also environment and economic threats. A holistic approach is too broad for this study. The resources in the environment, if managed properly, can enhance the environmental security in the region. (Poku et al., 2007). Over-exploitation of the region can also result in decreased security. The transitions in Africa create opportunities for frameworks to be tested.

Modeling Environmental Security in Sub-Saharan Africa

By applying the model presented in *Modeling Environmental Security in Sub-Saharan Africa*, (Figure 3), this paper analyzes areas of concern with regard to increasing vulnerability of people near Lake Victoria and Kampala. This model works well because the pollution involved in this area is composed of more than just environmental factors. This analytical tool accounts for dynamic factors such as cultural norms, economics and internal as well as external conflicts. The model lays out fundamental processes which all contribute to the potential for conflict. All

of these factors are at a confluence of human and natural environments where increased vulnerability due to pollution will occur.

Based on the practical application of this model, access to fresh water shows a negative correlation between instability and increased environmental stressors (Krakowka et al., 2008).

Appropriateness of the Model to Scope of Research

The model that Krakowka et al. discusses fits the research being done here because of the inputs that are available. The model is intended for analysis of Sub-Saharan Africa, and Lake Victoria is one of the most studied areas in the cultural, environmental and governance contexts. For this analysis, the human activity and non-sustainable processes will be absorbed into cultural factors. In this context, the cultural practices are contributing to both the non-sustainable and human activity processes. Many of the common cultural practices are non-sustainable and the human activities that are creating destabilizing affects are the result of a bad cultural belief that the environment will sustain itself through pollution. The environmental factors that are changing in the area also are affecting livelihoods and the way in which pollution is transferred through the system. Finally, the key involvement of government in the process has the potential to greatly affect how both cultural and environmental factors influence security.

The intriguing part of using this analysis is the eight potential outcomes. Many of these outcomes are already being experienced in the region and will only be increased by more varied or powerful destabilizing processes. The model relates these seemingly abstract events to one another allowing for positive influences to be identified and implemented.

Cultural Components of Environmental Security

For this section, the study will focus in on cultural practices, urban issues and industrial large-scale issues. Detrimental cultural practices are often a result of poor education in environmental pollution. Urban growth is uncontrolled and causes many types of land misuse. Government and Industrial influences work to control the interaction between the environment and people. Corporate dealings can provide large point source pollutants into the system.

Household Level Unsustainable Factors

The current land ownership system in Uganda is not conducive to development or environmental sustainability. In order to have secured land development three things are needed.

First, the landowner must have security from eviction from the land without just compensation or notification. Second, the land must be transferable from individual to individual. Without this ability, the land is essentially worthless to the individual if they wish to move to another location. Third, the landowner must be able to document that they own the land and be able to access those documents. This allows for economic growth as people can then borrow against their land. (Deininger & Ali, 2008). A study by Klaus Deininger (2008) reveals that without all three of these tenants of land rights, there is much less incentive to invest in the land, which a cultivator inhabits. When occupants become full landowners there is as much as

a doubling of soil conservation, a five-fold increase in tree-investment and increased productivity of the land (Deininger, 2008).

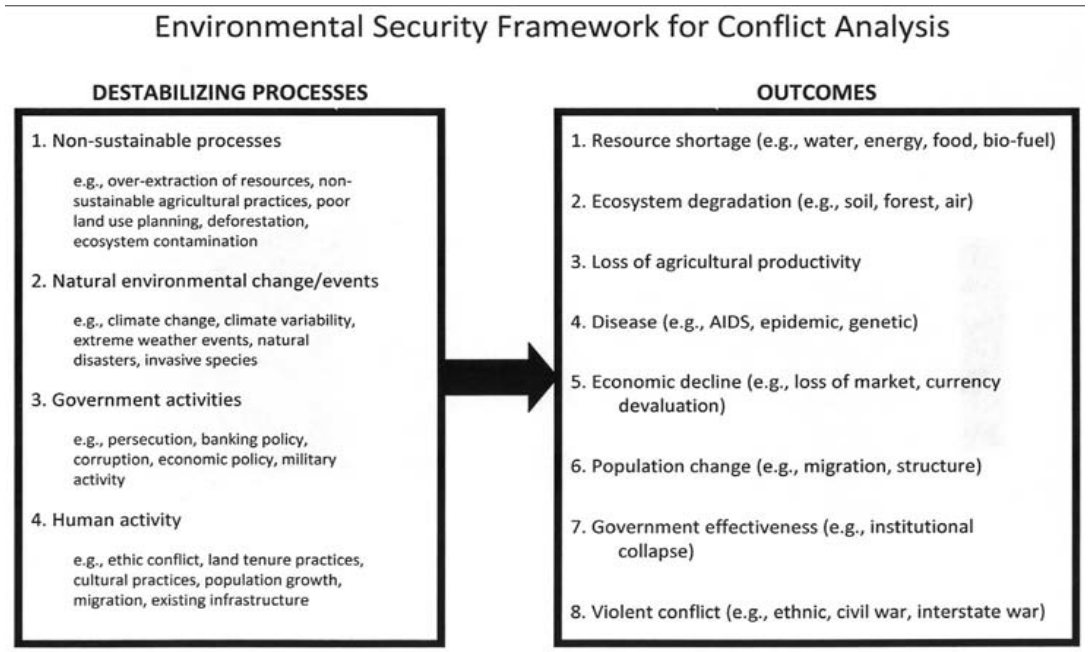

Figure 3: Environmental Security Framework for Conflict Analysis (Krakowka et al., 2008)

Cultural practices compound issues brought on by land rights. Unfortunately, one of the leading causes of pollution comes largely from nonpoint sources such as heavy metals. Nonpoint pollution is pollution that comes from many diffuse sources such as the contributions made by individuals. Motor vehicles are one of the main sources of non-point source pollution.

The use of lead-based gasoline by cars can significantly increase the amount of chemicals in the water, and the cultural and climatic necessity of washing cars increases the likelihood of heavy metals being washed off the cars (Kwach, 2009). With every easy convenience there is a cost and this one is the pollution of water (Kwach, 2009). Uganda's Environmental regulations would not allow this if they were enforced. NEMA has laws in place that would prevent such actions if they were enforced (Interviews, 2013).

Getting rid of both human and trash waste is another large issue at the household level. According to a professor from Makerere University, there is no centralized sewer system in the city. The majority of planned sanitation takes the form of septic tanks of poor quality that leak into the groundwater. In both rural and urban informal housing, pit-latrines drain directly into the ground. These pit-latrines also cause local pollution problems when rains cause overflow and spillage (Interviews, 2013).

These issues independently are not huge contributors to pollution, but when combined by a significant portion of the population the effect is amplified. Non-point source pollution has a great effect on the environmental degradation. If people are not trying to protect the environment on an individual level, even if reforms are

made on a larger scale, the environment will continue to be affected.

Urbanization Issues

The city of Kampala is a perfect example of uncontrolled urban growth. The population has boomed form 330,000 in 1970 to 1.5 million in 2009. This growth has expanded into the periphery and incorporated many satellite towns. In 2002, 39% of the total city population lived in informal settlements. These slums are expanding into the wetland areas causing pollution, which is normally filtered naturally by these areas, to flood both the slums and Lake Victoria in times of heavy rain. Areas of suburban agriculture often punctuate Kampala's slums. This agriculture is often polluted by bacteria prevalent in the pollution filled slums and the presence of heavy metals from polluted water. The National Environmental Management Agency identified wetland encroachment from urbanization as one of the greatest threats to the environment in Uganda (Interview, 2013).

This occupation of unplanned areas does not allow the government time to put infrastructure in place. People move in and essentially have electric, water or sanitation (Interview, 2013). Ultimately, they contribute to the waste problem by living in unplanned spaces. In developed countries, infrastructure goes into a development before it is populated, allowing sewer, water and other amenities to be put into place. Here, the opposite takes place and the waste is just dumped out in streets or into the Lake instead.

Industrial Level Issues

In addition to the actions of individuals, unregulated or unplanned economic ventures can result in large amounts of pollution. Two examples of this are the Mpererwe Landfill and the Kilembe copper mining district near Lake George. These areas both pollute the water supply of Lake Uganda. They are point source pollutants, pollutants, which originate at a single point or location, so identifying how to fix the problem can involve limited individuals instead of thousands living in slums or changing culture.

The Mpererwe landfill services the greater Kampala area. This landfill produces pollutants and they enter the groundwater. When they are not properly formed or maintained, leachate (liquid run off form the landfill) can have a drastic negative effect on the quality of the environment downstream from the landfill (Mwinganga, 2005). At the Mpererwe landfill, the leachate flows downhill without filtration into a wetland (Mwinganga, 2005).

The Kilembe copper mining district in Lake George Uganda, abandoned several years ago, lives on through its pollution to the surrounding area and Lake Victoria. Originally a main producer of copper, other more plentiful mines now operate in its place. This pollutant, like many point source pollutants, pollutes a great amount for the relative size of the operation. Kilembe was not a single mine but instead a region where many mines produced raw material for colonial export. The active mining operations left up to 15 million tons of mining tailings (Mwiganga, 2005). This rock has oxidized and increased acid mine drainage and acid rock drainage, which releases heavy metals into the water that naturally drains in the mine. These heavy metals are carried first into Lake George, then the Kagera River, then finally into Lake Victoria as seen in Figure 1.

Environmental Components of Environmental Security

In this section, the effect the environment has on human pollution is examined. Climactic variability is small-scale climate change that is not a long-term effect; instead it is a slight variation from the norm of what the climate is historically. Invasive species in Lake Victoria are unique because they have a large impact on vulnerability not only in the environmental realm, but also in people's livelihood.

Climate Variability

The largest climate issue is the recent and perceived prevalence of climate variability. Those interviewed stated that they can no longer accurately plan when to plant their crops (Interviews, 2013). Rainfall extremes either wash out crops or leave them dry and withering. These extremes also have the effect of temperature swings and other climatic stressors (Nyeko-Ogiramoi 2013). This varied climate prevents natural ecological inhabitants from maintaining their livelihood in the ecosystem. Once native species are threatened, invasive species such as the Water Hyacinth are allowed to encroach and cause more issues.

In an interview with leaders in the Uganda Water and Sanitation NGO Network (UWASNET) the issue of climate change or climate variability came up. In one individual's opinion, though climate variability was definitely a factor in recent droughts, a lack of foresight and planning for unexpected circumstances was to blame (Interviews, 2013). This view was contrary to what was said by some other NGOs, but UWASNET sees a larger picture than most individual NGOs and their experience is very valuable.

Invasive Species

Invasive species are not typically thought of as pollutants, but in the case of water hyacinth they serve as both a pollutant and an amplifier of other pollutants. Over the last 150 years (Plummer, 2005). The water hyacinth plant (Eichorina Crassipies), migrated into the Lake Victoria area and began to choke the shoreline (Opande, 2004). These plants pose a serious threat to the ecosystem and essentially are acting as another pollutant. Though the growth of this plant is not specifically a point or open source pollutant, it has many of the same effects on the livelihoods of the people living in the affected areas.

One of the main characteristics of the water hyacinth is a very rapid growth rate. This prevents the local people from effectively eliminating the weeds in their local area on their own. In only two years, the Winam Gulf of Kenya saw increases of as much as eight hectares in some areas. One issue with dealing with the water hyacinth is their mobile nature. Climate also has an effect on the prevalence of water hyacinth. There is a potential correlation between the blooming of water hyacinth and El Nino weather events. During years of increased rain there are significant increases in the mat areas of the water hyacinth. (Kiage, 2011).

Ultimately, the emergence of water hyacinth as the main macrophyte in the Lake Victoria system can be traced to the increased pollution of the lake. As a largely agrarian society, the areas upstream of all of the inlets to Lake Victoria are polluted from waste in the form of fertilizers or human refuse. Though water hyacinth could potentially be dealt with by mechanical or biological means at the surface of the lake, a better and more

permanent solution would be to reduce the number of pollutants that enter the lake. This is essentially treating the source of the problem instead of the symptoms. (Kiage, 2011).

Governance Components of Environmental Security

As previously mentioned, Uganda does not score well on the corruption scale. The government, though it has significantly progressed since the overthrow of Idi Amin, still has some major issues in the areas of land-use and the promotion of the state over individuals. The political future of the state is difficult to decipher. President Museveni has been elected into office several times, but these elections may not necessarily be free and fair. As a country with limited resources, Uganda's government needs to choose where it will enforce laws and regulate citizen actions. Currently, as demonstrated in an interview at the Ministry for Water and the Environment, the focus of the Ugandan government is trying to fulfill the right or entitlement of Ugandans to water. With this mandate heavily on their mind, political decisions are made to prioritize water over sanitation (Interviews, 2013).

Land-use as a Governance challenge in Uganda

Even though Uganda's constitution is one of the most progressive in sub-Saharan Africa, women are still not receiving as many benefits from the recent land reform in 1998. The problem is not legislation but implementation. Limited involvement of the national government had led to many communities not heeding the laws. Instead, some communities believe that women cannot own land or cannot inherit the land from their spouse upon his death. Corruption also plays a role in this; local leaders who should be administering the law often overlook injustices when they are in line with customary practice at the local level (Doss, 2012).

After the overthrow of Idi Amin, an agreement could not be made as to how the land would be divided up and the constitution was formed without a land reform provision. (Deininger & Ali, 2008). The 1998 Land Act was adopted to fill the shortcomings in the constitution and as a result, the first mechanism was established to allow land tenants to claim temporary leases of the land they resided on. However, the Land Act has also had some unintended consequences. The most critical issue is the funding of the enforcement arms of the national government. The increased regulation has been hurt by the bill's lack of a provision which taxes land owners and brings in additional revenue (Hunt, 2004). This causes more issues with corruption as bureaucrats are paid less and are more likely to accept bribes instead of performing their assigned state function. Also, the Act allows some leaseholders to claim they own the land and convert it to freehold, which allows them to avoid paying the rents to the government. Agriculturally this bill, which is the only real regulation of land use, has put pressure on banks to take more chances on loans that are backed by the ownership of land. The risk associated with these small loans is large because a single bad crop year could be very detrimental to the banks. This has discouraged banks from giving loans to new landowners. (Hunt, 2004). Funding is the central issue in the enforcement of this bill and it is evident that if reforms to the Act are made, it should be in the funding. Currently there are issues with parts of the Act such as

dispute settlement and women's rights, which could be fixed with more funding, but as always in Uganda there is a constant political struggle to rectify political goals with what is good for the country in the long term.

Through in depth surveys, Cheryl Doss found that very few independent women owned land. Most of the land owned by women was co-owned with their spouse. Even then, many were unsure that the ownership would be recognized within the community. Men are much more likely to come into ownership of land through inheritance. Women, if they have land, are usually granted land because their spouse had died or they have legally divorced and somehow got the land. Women's land rights are very important as it gives them security in a region where jobs are much more limited than men's. If a marriage falls through, often it is the woman who is disadvantaged. Maintaining land ownership can keep them from falling into a cycle of poverty for both them and their children.

Uganda's situation is not unique. In many African nations there are issues with urban growth and a general lack of planning. The system of land ownership in many African countries has been revamped after years of colonial rule. During colonial rule, Ugandan land was divided up between the Buganda king, smaller tribal rulers and the colonial power (Deininger & Ali, 2008). Blocks of land were grouped together and awarded to the Buganda king and his nobles. These land sections are now known as *Mailo* and are currently one of the main issues with land ownership. Beyond the king and noble landowners, there was no real ownership of land. The cultivators who lived on the land had to share their land rights with the colonial designated landowners (Deininger, 2008). Land ownership continued to be an issue and reform did not come about until the reign of Idi Amin. The post-colonial dictator transformed all land into lease-hold, which took ownership from individuals or nobles and put it in the hands of the national government, which may not have the people's best interests foremost in its decisions.

Urbanization and Corruption

Corruption in the form of bribes ultimately has four consequences, which all have a negative impact on the government's ability to regulate land. In addition, corruption leads to the destruction of local markets, reduces tax revenue, and takes control of the population away from the state. Bribes will act to destroy local markets, because people who cannot afford to pay the legal costs of running a business may not be able to operate due to the added pressure of bribes. The presence of bribery also incentivizes officials in the public sector to not do their job, as they may as well be accepting bribes like the rest of their colleges and they are not rewarded when they do work. Bribes often reduce the amount of tax revenue going to the government because individuals are able to pay off the officials who should be collecting those taxes. Finally, bribes are used by criminals to control the state and its derivatives such as the police (Houngnikpo 2006). Corruption relates to land use and the negative effects poor land use management has on the environment. All of the consequences of bribery result in current land use reforms not being reinforced. This essentially negates any positive effect on the environment land use planning would have. The country earned a ranking of 29 on a scale of zero to one hundred where zero is a highly corrupt (Transparency International, 2012). This

is exhibited in the urban sprawl that has enveloped modern Ugandan capitol of Kampala. Beyond corruption in the form of bribery, other forms of political corruption have major negative effects.

In order to maintain political favor, President Museveni has circumvented the public land planning policies that are made by the Kampala City Council (KCC) and is instead working with the non-state actors at the local level. One such example is the motorcycle taxi drivers who he allows to not pay taxes. This support from the president enables them to evade city made policies (Goodfellow & Titeca, 2012). In nearly every study on issues land or otherwise in Africa, at some point corruption is labeled as a cause. Museveni is not the only politician in Uganda who is guilty of putting his own goals ahead of the people. As seen in other areas of the world with informal sectors, getting rid of the informal and peri-urban housing is not an option. Politicians rely on the slums to get voted into office. If a slum is cleared out, the voter base for that politician is gone. This makes both infrastructure development in these areas and good land use practices very difficult (Interviews, 2013).

Exploring the Eight Environmental Security Outcomes

The Krakowka et al., (2008) model provides eight outcomes that correlate to the previous four environmental degradation inputs. Many of these are already occur in Kampala and Lake Victoria.

Resource Shortage

In most parts of the world, pollution due to heavy metals is worrisome because it is difficult to remove from water supplies through traditional filtration means. In the countries surrounding Lake Victoria, this is an even greater worry because a large percentage of the population relies on untreated or only slightly treated water from the Lake. Because of the increased pollution, the National Water and Sewer Corporation (NWSC) installed an offshore pipeline, which stretches 1.5 km into the lake to a depth of 11m (Kampala Supply and Sanitation Expansion Program, 2012). Even water that is treated with chemical additives will still sometimes contain heavy metals and the cost of treating this water is also very high. A much better solution would be to prevent the heavy metals from entering the system in the first place, but bad cultural and commercial practices have left a legacy that will be difficult to overcome.

Ecosystem Degradation

Heavy metals tend to get more concentrated the farther up the food chain they travel in a process known as bio-accumulation and the vegetables are grown in soil and near water that is significantly more contaminated than in rural areas (Owor, 2006).

The vegetables surveyed all had unhealthy amounts of both cadmium and lead in them. The levels of these two metals are outside of the guidelines set by the World Health Organization and can pose serious risk to human health (Mbabazi, 2010). With all of the other stressors on local inhabitants' lives, the risk of lead poisoning will not increase their overall health. Farther down the water flow, heavy metals are even more of an issue and become more concentrated. This, combined with environmental factors, can amplify the concentrations of heavy metals.

Prior to the invasion of the water hyacinth, other floating plants such as papyrus, elephant grass and Azolla nilotica instead dominated Lake Victoria. The water hyacinth has competed and pushed nearly all other macrophytes out of the area, resulting in a reduction in biodiversity and possibly the extinction of the *Azolla nilotica* that was previously found at the mouth of River Nyando. (Tiwari, 2007). The reduction in biodiversity even effects the wetlands found in the shores. Lagoons, which previously were one of the main filtering systems of the Lake, are now replaced with floating mats of water hyacinth. This has a double effect as pollution leads to increased nutrients in the water, resulting in the growth of more water hyacinth in addition to the increased potential of algal blooms to emerge. (Tiwari, 2007). One positive side effect of the spreading water hyacinth is the small fish often used by fishermen for bait tend to follow the mats, but this one good hardly outweighs the negative repercussions. (Minakawa, 2012).

Loss of Agricultural Productivity

The mercury found in the belly fat of Nile Perch likely originates from one of many battery-recycling plants where old battery mercury is allowed to flow directly into the river (Ogwok, 2009). These mercury concentrations make the fish, an important protein source, unhealthy to consume. Heavy metals and other pollutants are put into the ground as a result of waste. This waste then enters the ground water and is transferred to other areas, which are then polluted. In the peri-urban areas of Kampala, locals try to supplement their income by growing limited vegetables during the growing seasons. These vegetables also have the potential to provide them with nutrition they might not otherwise be getting because of a low income. Unfortunately, this nutrition is grown in tainted ground, and as previously mentioned vegetables grown in the presence of heavy metals can have a net negative effect.

Disease

Water hyacinth has long been seen as a noxious weed inhabiting the shores of Lake Victoria. The main issue with water hyacinth is not the plant itself, but the creatures it carries. There is a proven correlation between the water hyacinth and increases in malaria and schistosomiasis (Opande, 2004). The Hyacinth provides a shelter for *An. Funestus* and *An. arabiensis* (mosquito) larvae, but only when it is stationary and caught in trees next to the shoreline (Opande, 2004). Unfortunately, the trees are planted to discourage hippopotamus from residing on the shores near areas of human activity. These trees were never a problem causing vectors prior to the emergence of the water hyacinth. Waves could pass through the area and would disturb the vector larvae, which tried to take root in the native hippo grass. The water hyacinth in concert with planted trees allows for a large increase in vector larvae along the shores in the primary areas where locals are active. A larger issue though is the use of water hyacinth by schistosomiasis snails, which carry schistosomiasis, commonly known as African sleeping sickness, as a method of moving from one inhabited area to the next.

Though water hyacinth is not a good environment for malaria vectors while free floating, the schistosomiasis snails have been found in abundance on these uprooted mats. The schistosomiasis snail

will latch onto a floating mat of water hyacinth after a storm and essentially "ride" the plant until it becomes trapped in a lagoon or in trees on the shoreline. There, the snail will transfer to hippo grass that is both harvested by locals and located in areas where water is commonly retrieved (Ofulla, 2010). Typically, the floating water hyacinth is ignored in conservation attempts leaving the schistosomiasis snails on these floating beds to travel across the lake. (Opande, 2004). In the short term they do not have an effect on communities, and it appears as though the mats can be dealt with after they have stopped floating and impacted a community. This is too late to prevent the introduction of schistosomiasis snails into the local fauna. Areas traditionally free of schistosomiasis have seen dramatic increases as a result of the water hyacinth.

Economic Decline

Evidence of economic decline in Uganda is difficult to pinpoint as a result of pollution. Uganda saw an increase in GDP of 7.1 from 1992 to 2011 and on an annual basis is on par or better than the rest of East Africa (African Economic Outlook). Long-term pollution will, however, have a negative effect on the local fishing community. In short bursts, fish will adapt and filter the pollution using their fatty tissue and liver to store toxins (Ogwok, 2009). Luckily, the monsoonal rains, giving the Nile Perch time to recover, sweep pollution into Lake Victoria. Over time, for reasons previously discussed, pollution builds up in the Lake and accumulates. When Perch are exposed to long-term pollutants, their livers are overloaded resulting in excess deformation and immune deficiencies (Ogwok, 2009). The fisherman population in the immediate area around Lake Victoria is a substantial part of the population, which is vulnerable to the changes in fish population. There is also the potential for conflict in this area as fishery resources dwindle. There are already issues emerging over fishing in Uganda. At Lake Albert on the western border between Uganda and the Democratic Republic of the Congo, fishermen from the Congo poach in Ugandan waters (Interviews, 2013). Lake Victoria is much larger than Lake Albert and any issue that takes place in this smaller lake we can expect to see to a much larger degree.

Population change

Ugandan population change had two parts. The first is the issue of the increase in population and the second is in the location of the people. Issues with development of Peri-Urban sectors and wetlands have already been discussed. As people continue to move into less than ideal land in an informal setting, there will only be an increase in poverty, as the government cannot provide infrastructural services such as water and sewer. The rural to urban migration is driven by the hope that more opportunity and services will be found in the city. This will only increase if water security issues in the rural areas increase. The increased urban population will require more water and this water must come from Lake Victoria, which is not viable if it is polluted.

Government Effectiveness

The Ugandan government has definitely seen issues emerge from environmental degradation factors. The difficulty with the water supply is not only a drain on the government, but it is also reduces the legitimacy of the government. As stated earlier, most Ugandans see clean water as a right. If a state is not providing for its

constituents what they believe is a right, the people have no reason to have faith in the state. Also, if people do not know about environmental regulations or they are not enforced, they will not make positive changes that support the environment.

Conflict

Resource scarcity has already begun to sow the seeds of conflict. As discussed earlier, in the interview with the Joint Effort to Save the Environment (JESE), there was a high level of conflict when a good water source was installed in the area and different people tried to get access to it. JESE has more expertise in rural areas, but in Kampala there is a similar situation as discussed. Significant competition occurs over the 5% of clean springs.

Conclusion

Analyzing the Lake Victoria region at this time is very significant because of the stage in development which Uganda finds itself in. Uganda has only begun to develop large industry and has the potential to grow this facet of its economy in a green way or in a non-green way. Precautions now could save Kampala for a future struggle with widespread pollution. If nothing is done now to reverse the pollution trends currently seen, the costs of later trying to clean up the pollution will be astronomical. The cultural impacts on this issue are a hard piece to solve.

Changing a culture takes years of education and strict regulation by the government; something that Uganda doesn't seem very inclined to do.

Though some environmental factors such as when the rains come are not predictable, others such as invasive species are. Those that can be dealt with should be in order to secure a better future. The Ugandan government needs to reduce corruption in order to better secure its position in the future. The Ugandan people want a government who they can work with and are proud of. By not taking part in reducing pollution, the government is setting itself up for failure. The environmental security outcomes all suggest that the environmental destabilizing processes have already taken a toll on the vulnerability of those who find themselves interacting with the environment on a daily basis. Finally, in order to avoid future conflict the Krakowka Framework must be analyzed and the links between the destabilizing processes and outcomes in order to find the area most needing change.

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A Wealthy Land Lost: Lake Kivu's Volatility

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Abstract

Over five million people died in the Democratic Republic of the Congo between the onset of war in 1996 and the Second Congo War's formal end in 2003. Most of these deaths occurred not on the battlefield, but from the 3.4 million internally displaced persons (IDPs), most of whom were in the Kivu provinces. Legacies of this dark chapter of history live on, as atrocities continue in the country's eastern Kivu provinces. This paper will analyze the social ecological factors that make Lake Kivu and its banks one of the most volatile areas in the world. A brief explanation of the Great Rift Valley's physical geography will show the dichotomy between the region's wealth versus despair. Next, the resource trade systems of Lake Kivu's banks, forged by colonialism and war, exploit rather than help the population. Finally, a lack of governance from the leaders of the DRC and its neighbors allowed the ruthless extraction of natural resources through a myriad of rebel groups. The interaction between physical geography, resource trade, and poor governance has turned what should be one of the wealthiest places on earth into one of the most volatile.

"Understanding what happened in Central Africa under colonial rule lays the foundation for understanding today's conflicts."

Introduction

When Kakule Nguramo was five years old and living in Goma, Democratic Republic of the Congo (DRC), his father leaned over to him and said, "Those are refugees. There is war in Rwanda." During the same period, Alexander Abia's father called his wife, living with Alex in Swaziland, and told her that Kigali was safe enough for their family to return home. Both Alex and Kakule are now graduates of the United States Military Academy at West Point. Their countries of Rwanda and DRC, respectively, have invested in the education of these two promising future leaders (among others) in the hope that they might restore order to the region after decades of violence. Leadership is often cited as a major factor in the Kivus' volatility. The three Presidents of the DRC have been Mobutu Sese Seko, Laurent Kabila, and his son Joseph Kabila, in that order. All three have come to power violently, reflective of the country they have ruled.

International attention has lately been focused on regions of severe and seemingly unending conflict. Examples such as Kashmir, Iraq, the West Bank, and Central Africa have been featured daily on worldwide news highlighting the struggles of the people living in those areas. However, media reports tend to miss one of the most volatile areas, Lake Kivu, on the border of the DRC and Rwanda. The

eastern region of the DRC has been engulfed in almost constant fighting since the First Congo War erupted in 1996, fuelled by a myriad of complex, but interrelated factors. Additionally, the region immediately surrounding Lake Kivu faces many natural hazards and disaster threats that add uncertainty to this populated area. Lake Kivu lies in Africa's Great Rift Valley, stretching from the Red Sea to Mozambique. Its banks are one of the most densely populated areas on the continent. This paper breaks volatility of the Kivus into four categories: governance, trade, environmental security, and well-being.

Study Area Definition

Lake Kivu is located in Central Africa, straddling the border of the DRC and Rwanda. North and South Kivu are the two easternmost provinces of the DRC. The lake spans from 1.5° to 2.5° S and covers 2,700 km^2, separating the DRC and Rwanda by 48 km at its maximum width (Veregin, 2010). Lake Kivu's situation is extremely significant, as its urbanized banks, geographic surroundings, and existence as a natural state border affect political, economic, and environmental systems. Goma is the largest city in the region and the capital of North Kivu, with a population of over 1 million (MONUSCO, 2013). Lake Kivu is situated in the Great Rift Valley of Africa, created by a tectonically active divergent boundary. Mount Nyiragongo, located 19 km north of Goma, is a very active volcano because of this tectonic boundary (National Geographic, 2011). Climatically, Lake Kivu lies in the Inter-Tropical Convergence Zone (ITCZ), but has a high altitude of over 4,700 feet (Veregin, 2010). North Kivu is the convergence point of the DRC, Rwanda, and Uganda, sharing borders with both neighbors. Lake Kivu, and the rest of the region's, site and situation lay the foundation for its complex network of overlapping and interrelated systems.

Given the physical geography of the African Great Rift Valley, and the Kivu provinces in particular, this area should be among the wealthiest on earth.

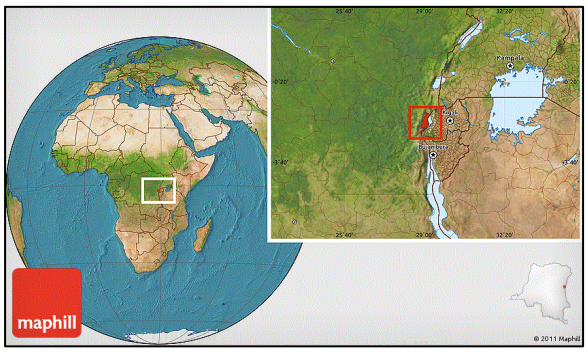

Figure 1: Site and Situation of Lake Kivu (Maphill, 2011)

The climate and abundance of resources are positive factors, while the divergent tectonic boundaries pose natural threats as well as advantages. The Kivu provinces are in the perfect position climatically; they are within five degrees of the Equator and also lie on a high plateau (Veregin, 2010). Being so close to the Equator means that the Kivu region has elevated temperatures, which are moderated by altitude, and also lies in the Intertropical Convergence Zone (ITCZ) which brings heavy rainfall. This periodicity makes it possible for the crops in the rift valley to have two growing seasons, which is extremely important for agricultural production. In other parts of the world, these higher temperatures work against agricultural production because only some crops can grow in that climate. For example, the Amazon Rainforest lies in the same latitude as Lake Kivu, but much lower altitude, and is much less conducive to agriculture because of the thick jungle (National Geographic, 2011).

The Great Rift Valley splits into east and west divergent faults, elevating the land in between them (Veregin, 2010). This creates an oval-shaped plateau with rift valleys on either side, and the western valley is home to Lake Kivu. This combination of climate, elevation, and volcanic soils give the Kivu region an excellent agricultural advantage.

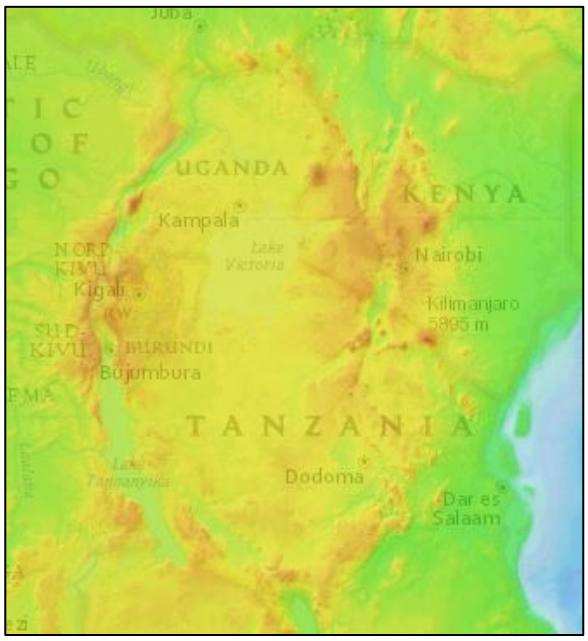

Figure 2: Great Rift Valley (National Geographic)

Along with the advantages the rift valley gives Lake Kivu and its banks, there are also many natural hazards that come as a result of the physical geography. There is a significant amount of methane dissolved in Lake Kivu, and the concentration increases with depth (Schmid, Halbwachs, and Wehrli, 2004). After the existence of this methane deposit was discovered and confirmed, recent scholars moved to analyze the ramifications of such a large amount of natural gas in a very populated space. Cameroon's Lake Nyos presented a similar scenario. It was the force behind the disaster that killed 1700 on August 16, 1984 (Kerr, 1987). Volcanic activity caused a bubble of carbon dioxide to form at the bottom of Lake Nyos, and a displacement of water disturbed the gas enough to make it erupt to the surface. Since carbon dioxide is denser than air, it hugged the ground and traveled in streams, asphyxiating anyone in its path (Ibid). A survivor of the Lake Nyos disaster retold the incident in an interview, recalling how fast the gas took the lives of those around him (Weisburd, 1985). Because Lake Nyos and Lake Kivu are two of three lakes in the world capable of limnic eruptions, disasters at Lake Nyos are indicative of Lake Kivu's potential for disaster. The methane bubble under Lake Kivu poses a tremendous threat. Should the bubble burst today, over 2 million people could potentially die instantly. However, the natural gas could also be a potential resource for the region, providing a massive amount of energy (Doevenspeck 2007). In fact, private companies such as the Private Infrastructure Development Group (PIDG), are safely extracting the dissolved gas. The situation with Lake Kivu's gas provides an excellent case study through which to examine the complex problems facing Central Africa.

Although the volcanic activity surrounding Lake Kivu creates threats, the divergent boundaries have created the numerous mineral deposits in the region. The magma bubbling through the crust to the earth's surface in the western branch of the rift valley provides the heat and pressure over time to cause the array of minerals to form (Rüegg, 2012). All of the DRC is resource rich, but the Kivu provinces contain an especially high density of rare earth metals (See Figure 3). For example, coltan, an element used as a superconductor in electronics, is found almost exclusively in the eastern parts of the DRC (Tervuren, 2005). The combined positive factors of

Kivu's perfect climate and vast mineral wealth indicate that it should be one of the richest areas on earth. However, economic and political factors have prevented the DRC from reaching its potential.

History

Key to understanding the history of the DRC's current political turmoil is its turbulent transition from colony to independent state. Different European powers had very different methods of colonial rule. For example, the Belgians used a brutally-driven, direct rule of subjugating the native Congolese, while the British used indirect rule of elevating an arbitrarily selected ethnic group to power (De Blij and Cole, 2007). Understanding what happened in Central Africa under colonial rule lays the foundation for understanding today's conflicts. Most of the political analysis of the Kivu provinces has to do with President Mobutu Sese Seko's time in power, and much of the remainder focuses on Laurent Kabila and his son, Joseph. Mobutu's emplacement as President of Zaire in 1965 marked the beginning of the DRC's modern political system, but colonial politics also played a very key role. Because of the way in which these Congolese institutions crumbled after independence, many have put President Mobutu in their crosshairs.

The balkanization of the Congolese military and government structures is relevant to the Kivus because it created the lack of governance seen in the region today. President Mobutu created a culture of corruption in which heads of state to follow were trapped. Mobutu was thrust into his seat after a military coup backed by western countries, including the United States. Because of his own path to power, he was constantly wary of Zaire's military, fearing another coup d'état. To dissolve this perceived threat, Mobutu appointed senior officers based on loyalty, often selecting leaders from his own tribe (Stearns, 2013). Choosing personal loyalty over commitment to the nation undermined the entire Congolese military because performance no longer mattered under President Mobutu as long as officers were loyal to him. This concept easily transfers to the Congolese mining industry, where corruption was equally rampant.

During his 30-year reign, President Mobutu created Gécamines, a state-owned mining company in which "taxes taken together amounted to 50% of the trading value of the production at the Congo border," (Radmann, 1978). While exploitation of natural resources in the Congo dates back to Leopold II's extraction of rubber in the late 19th century, Mobutu's Gécamines marks the first time since independence that a Congolese leader stole mineral wealth from his people. While mainly operating in Mobutu's home province of Katanga, Gécamines contributed to government corruption and still does to this day (Chene, 2010). Much of this revenue was used to line the pockets of senior officials in return for loyalty, landing Zaire with the title of most corrupt state in the world in *Business International*'s 1980-1983 corruption index (Mauro, 1995). Because of this theft, the Congolese people could not benefit from the country's natural mineral resources, impoverishing the population and sending the state into an era of decay. The 30 years that President Mobutu was in power drove Zaire into the ground, destabilizing the Kivu provinces and making them susceptible to future violence. The lack of leadership, two horrific wars, and a general lack of governance in this mineral-rich

region has left the Kivus vulnerable to exploitation.

It is also impossible to grasp the complexities of the Eastern DRC without understanding Rwanda's history. Under the colonial control of Germany and then Belgium, Rwanda's minority ethnic group, the Tutsis, were placed in power. Hutus, the ethnic majority, were subjugated while the powerful governmental and military positions were given to Tutsi leaders (White, 2009). While there was a historic divide between agrarian and pastoral tribes, this ethnic divide was magnified exponentially under colonial rule (Stearns, 2012). Leading up to the country's independence in 1962, there was a "Hutu uprising in which hundreds of Tutsi were killed and thousands displaced," (UN, 2013). When the Hutu majority held elections in 1961, 120,000 Tutsis had already fled to neighboring countries. By the 1980s the number of Tutsi refugees had increased to 480,000, with a vast majority in Uganda, Zaire (Now the DRC), Burundi, and Tanzania (Ibid). This is when Cadet Abia's father joined the newly-formed Rwandan Patriotic Front (RPF), whose goal was to regain Tutsi citizenship in Rwanda.

The RPF was based in Uganda, and many of its leaders had fought under President Yoweri Museveni in the Ugandan civil war which overthrew dictator Idi Amin. With Ugandan backing, the RPF launched its attack on Rwanda in 1990. By 1993, the Tutsi guerilla fighters had reached Kigali and a peace deal was made with the ruling Hutus, ensuring equal representation in the government. This deal, however, lasted only a few months before the violence continued on a much larger scale (Stearns, 2012). During the Tutsi advance towards the capital and during the months of peace, Hutu extremists broadcasted anti-Tutsi propaganda over national radio stations. Ethnic tension between the two Rwandan peoples was triggered by the shooting down of Hutu leader Rwandan President Juvenal Habyarimana's plane (Metzl, 1997). It is unclear whether the plane was targeted by Tutsi fighters or if Hutu extremists killed their own leader in order to ignite the genocide. In either case, "within thirty minutes of the shooting down of the airplane…barricades went up and the killing began," (Ibid). From the plane crash on April 6, 1994, to the RPF claiming control of the whole country on July 4, over 800,000 Tutsis and moderate Hutus were killed (UN, 2013). When the RPF gained power, Hutu *genocidaires* along with innocent civilians feared revenge from the Tutsis, and fled Rwanda.

1.1 to 1.25 million Hutus flowed into Zaire following the end of the Rwandan Genocide (Emizet, 2000). Refugee camps in the eastern Kivu provinces of Zaire contained countless civilians suffering in absolute poverty, but also harbored elements of the exiled Rwandan Armed Forces (FAR) and Interahamwe, the *genocidaires* who had just slaughtered almost a million innocents (Stearns, 2012). President Mobutu, in a position to resolve conflict with Rwanda diplomatically, only worsened the situation. The President could have disbanded the criminals or sent them back to Rwanda for prosecution, but instead he "let these [ex-FAR] troops cross the border and settle in refugee camps without being disarmed," (Emizet, 2000). Paul Kagame, RPF leader and President of Rwanda, was enraged by President Mobutu harboring the killers of his people. He formed a coalition of African nations including Uganda, Angola, and Burundi to overthrow Zaire's government. The international force invaded in September of 1996 and replaced

President Mobutu with Laurent Kabila in May of 1997 (Stearns, 2012). The First Congo War is a clear example of how political decisions in Kinshasa and Kigali destabilized the Kivus.

Conceptual Framework

In recent years, vulnerability analysis has surfaced as a key tool to gauge a place's geographic and environmental well-being. Dr. Scott Collins introduced is framework for social-ecological research, which is a circular model in which geographic presses and pulses drive social and biophysical templates. Additionally, Dr. Amy Krakowka developed an environmental security framework for conflict analysis. Her framework argues that non-sustainable processes, natural environmental change / events, government activities, and human activity drive the breakdown of environmental security. Although many excellent models exist for quantifying volatility, they are best fitted to their specific area of study. For example, a model which accurately depicts rural volatility may not be suited for an urban environment. The two frameworks below, without and with conflict, are developed to address the unique social, physical, and geopolitical conditions of the Kivu regions.

This model depicts the complex relationships between key factors in a resource-rich, urban-dominated environment. First, each factor in the model will be defined, and then the connections between them explained.

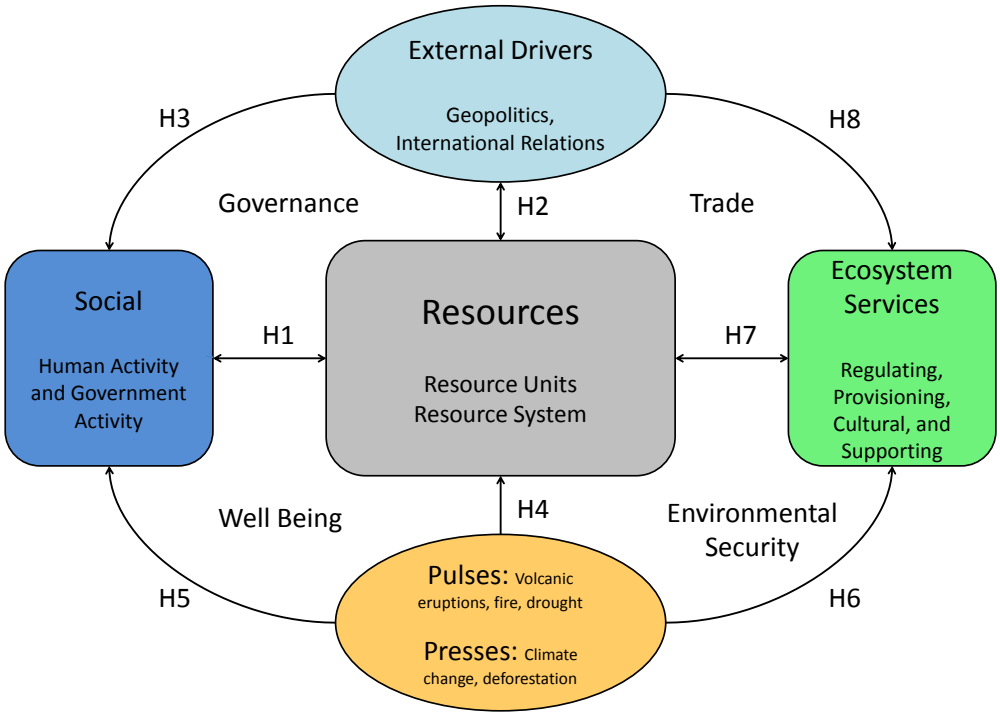

Figure 3: Kivu Volatility Model without conflict

Lake Kivu and its surrounding region is one of the most **resource**-rich areas in the world, with coltan as the most valuable today (Schmidt-Eisenlohr, 1978). Both the units of a given resource and the system under which it is controlled are important, as they are both necessary for sustainable profit both monetarily and socially (Ostrom, 2009). While resource scarcity can often lead to conflict, these vast resources in conjunction with a lack of control work to destabilize the region.

Social factors are the human and government activity internal to the region and its state. Human activity exists outside of the government and includes ethnic conflict, land tenure practices, cultural practices, population growth, migration, and existing infrastructure (Krakowka, Haimel, and Galgano, 2012). While international government activity is an external driver, local and state government activities fall into this category. Because of the scale of the DRC, governance is difficult to achieve from its capital on the western border to the eastern provinces. For this reason, the Kivus' lack of governance is its most defining factor in this category.

External Drivers consist of specifically international actors affecting the Kivus, whether directly or indirectly. For example, during the Second Congo War, Rwandan and Ugandan forces fought fiercely to control mines not only in Kivu, but throughout the country (Stearns, 2012). Foreign involvement is not new, as Belgian involvement under King Leopold II was aimed at rubber extraction. The geopolitical situation with respect to the Kivus depends on both international actions involving the study area and world events.

Presses and pulses are long-term and short-term geographic factors that adversely affect the Kivus. Presses are constant strains stemming from the region's physical geography, while pulses are point events which can devastate the local population in a short period of time (Collins, 2011). The Kivus are home to many different presses and pulses. Deforestation driven by intense mining operations is a major press in the region, as is climate change (IES, 2008). Pulses are present in the Kivus as well in the form of Mount Nyiragongo, an active volcano which erupted in 2002 and destroyed central Goma, and also sent lava into Lake Kivu (Lorke et. al., 2004). This event triggered fear of another potential pulse, a large bubble of carbon dioxide and methane layering the bottom of the lake, which could asphyxiate everyone on its banks if brought to the surface (Doevenspeck, 2007). While the Kivu provinces have great geographic advantages in some respects, these hazards pose serious threats.

Ecosystem services are products of the environment that affect both individuals' choices and press-pulse events. These services fall into four categories: provisioning, regulating, cultural, and supporting (Collins, 2011). Provisioning is defined as the "food, fiber, and fuel" the ecosystem provides Kivu's population. Because regulating processes like nutrient filtration and pest suppression are less visible to decision-makers, the forces which maintain balance in the ecosystem often go overlooked (Ibid.). Cultural ecosystem services are recreation and aesthetics, dominated in the Kivus by the mountains and valleys of its folded landscape. Finally, supporting services are primary production and nutrient cycling that the population interact with directly (Ibid.). Because of Kivu's intimate

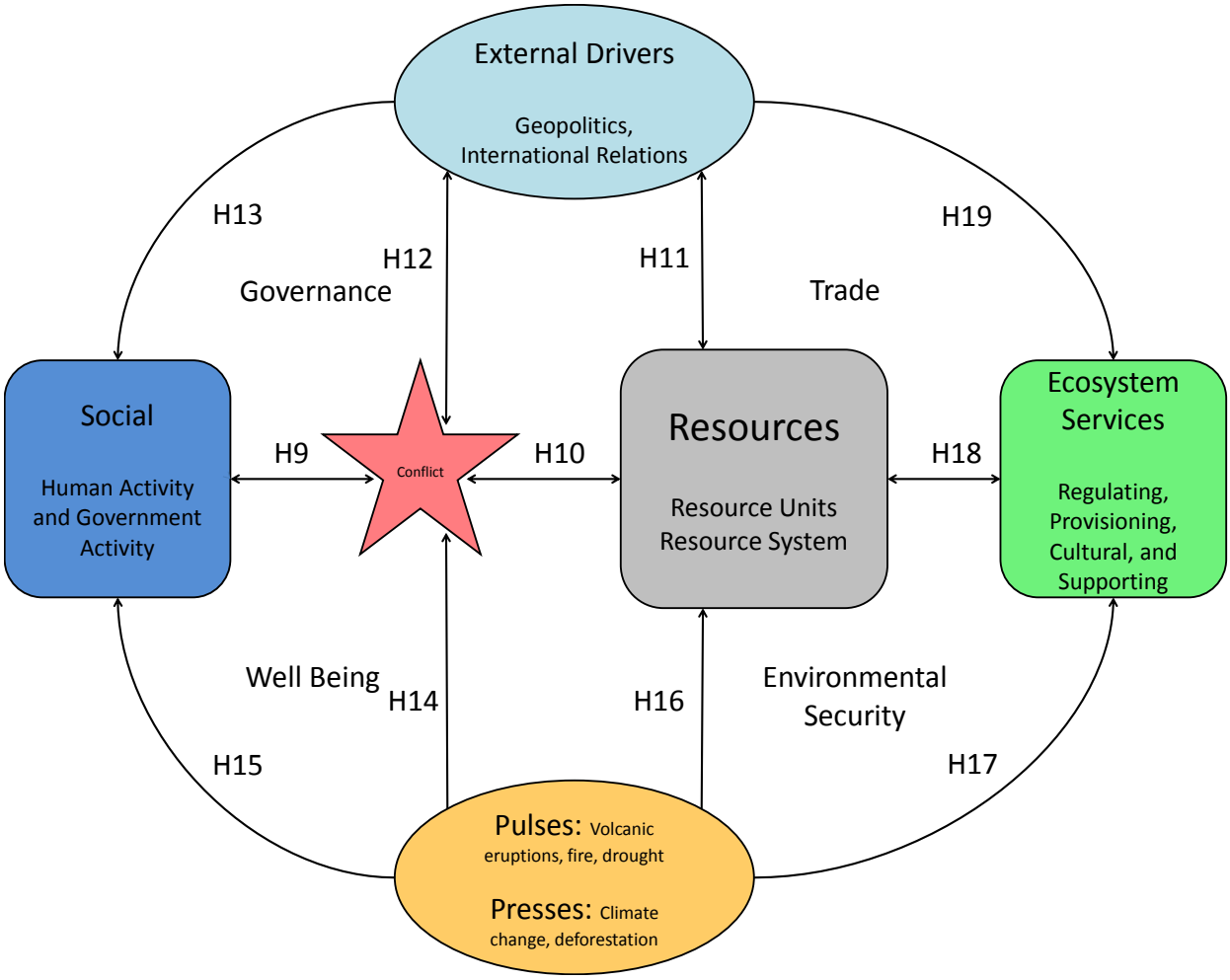

Figure 4. Kivu Volatility with conflict

relationship with its ecosystem, these four types of services play a vital role in the stability of the region. The top-left quadrant represents governance in the study area, analyzing who holds real authority; the top-right quadrant represents resource trade both within the target country and across international boundaries; the bottom-left quadrant represents individual well-being; and the bottom-right quadrant represents environmental security; all of these factors are linked by the central presence of mineral resources, and made more volatile by geographic presses and pulses. H1-H8 correlate to the below hypotheses, which serve to focus analysis of the research area. H1- The abundance of natural resources in the Kivu provinces makes it an area of interest for the DRC's national government. Additionally, the lack of governance at the national and local levels has destabilized resource extraction and increased volatility in the region; H2- Just as the Kivus are an area of interest for the DRC, their resources make them a target for foreign actors, who are closer spatially than Kinshasa's leaders; H3- The actions of foreign governments affect how the DRC and Kivu governments function, and can keep them from

functioning at all; H4- Press-pulse events place both long-term stresses and point, high-impact damages on resource infrastructure (Collins, 2011); H5- Presses shock the local and national governments, and any major pulse would devastate the local population and government systems; H6- Presses such as deforestation and climate change slowly damage ecosystem services over long periods of time, while pulses like the potential eruption of Mount Nyiragongo or the Lake Kivu methane bubble would effectively halt local ecosystem services (IES, 2008); H7- If ecosystem services in the Kivus decrease, then the demand for natural resources will increase and strain those resources' systems; H8- External drivers can both positively and negatively impact ecosystem services. International institutions calling for improved environmental practices are positive, while external pressure to produce resources can harm the local ecosystem. Figure 3 depicts a model in Kivus without conflict. However, peace has seldom been reality in this region since the First Congo War in 1996. The second model (Figure 4) injects conflict as the central factor together with natural resources.

All of the factors from the peacetime model, and the relationships between them, remain constant in the new model. However, **conflict** takes many different forms, and each one stresses the overall system. The First Congo War was a politically fueled, westward drive to overthrow President Mobutu by a coalition of many Sub-Saharan African states (Stearns, 2012). Less than a decade later, conflict in the Kivus was fundamentally different, centered almost entirely on mineral exploitation (Montague, 2002). These different types of conflict affect certain parts of the volatility model more than others. For example, the First Congo War altered the social factor more than minerals because it overthrew a regime which had been in place for over 30 years (Stearns, 2012). Although the outbreak of conflict pushes the Kivus' volatility to an extreme state, the fundamental structure changes only slightly. New hypotheses—H9, H10, H12, and H14—are the result of conflict entering the study area. H9- Conflict and Social factors are intimately related, as the Congolese government has an immense capability to affect any conflict either as a stabilizing force or a belligerent itself; H10- Minerals do not necessarily spark conflict, though they provide both an economic incentive to sustain ongoing conflict and the means to do so; H12- Foreign states play a major role in Eastern DRC conflict, such as Rwandan and Ugandan influence in the Second Congo War; H14- Pulse events can trigger immediate conflict through mechanisms such as displaced populations, while presses like climate vulnerability make communities less prepared to cope with conflict (Malcomb, Weaver, and Krakowka, 2014).

These two models are shaped by past events, and the results are expected to follow the historical trend. Complex problems of governance, trade, wellbeing, and environmental security have dominated the Eastern DRC for over 20 years. Sadly, ongoing conflict and corruption are expected to provide the means by which to validate the Kivu Volatility Model.

Governance

The qualitative nature of these two models makes their results difficult to measure. To overcome this, the four quadrants of the model will be examined to further under-

stand the relationships between factors. Kivu's lack of governance is a key factor in its volatility, as it prevents the region from defending against and responding to geologic and political threats. There are many contributing factors, and complex relationships between each factor and different components of the conflict model. The DRC's geography makes governing its vast territory extremely difficult (Nguramo, 2013; Stearns, 2012). First, Lake Kivu shares its banks with Rwanda, causing a lack of the model's social component and an increased interaction with external drivers. This causes an increased concentration of violence near the border, as Figure 5 demonstrates. Secondly, 1500km lie between Kinshasa and Goma, which causes a disconnection between the DRC's capital and its eastern, most populated provinces (See Figure 6).

Kivu became involved in the aftereffects of the Rwandan Genocide by proximity, which drew it into the First Congo War (Stearns, 2012; United Nations: Rwanda, 2013; White, 2009). Legacies of the First Congo War caused the next conflict to be more complex, and fighting in the Kivus was catalyzed by a lack of connection with Kinshasa (Stearns, 2012; Reyntjens, 2001; Montague, 2002; Emizet, 2000). From the end of the Second Congo War to present day, the area immediately surrounding Lake Kivu has not seen an improvement in governance, maintaining its vulnerability to conflict (Lawson et al., 2010; Kodi, 2009; Stearns, 2012). This history of inaction shows the weakness of the social-conflict relationship caused by a lack of governance, allowing external drivers to have more influence, and weakening the region's future responses to press-pulse events.

Trade in Resources

Kivu's vast mineral wealth makes prosperity possible, but decades of extraction and exploitation have corrupted the DRC's trade network. Rooted in colonialism, Congo is no newcomer to resource-related conflict (Stearns, 2012; United Nations: Rwanda, 2013).

Throughout the First and Second Congo Wars, military objectives shifted from political to resource-based (Stearns, 2012; Reyntjens, 2001). A war which started as a justified invasion to topple a dictator turned into fighting over minerals by coalition members (Stearns, 2012). This conflict leaves a legacy seen today by rebel groups, along with Rwandan and Ugandan militaries, holding mining towns and illegally selling minerals to fund their militant campaigns, making $150 million per year (Carlson, 2006). What could be a prosperous, mutually-beneficial trading relationship has mutated into a corrupt system of exploiting the local people and their land. This shows the detrimental relationship between external drivers, resources, and conflict present in the Kivus today. Similar to the relationship between external drivers, resources, and conflict, social institutions also take advantage of the Kivus' mineral wealth. Under President Mobutu Sese Seko, Zaire's corrupted resource trade was institutionalized (Stearns, 2012; Wrong, 2000; Radmann, 1978; Peemans, 1975). Companies like Gécamines embodied Congolese kleptocracy, allowing politicians to line their pockets. Although corrupt, this national theft occurred without violence. International and non-state actors are the main perpetrators of mineral extraction through violence.

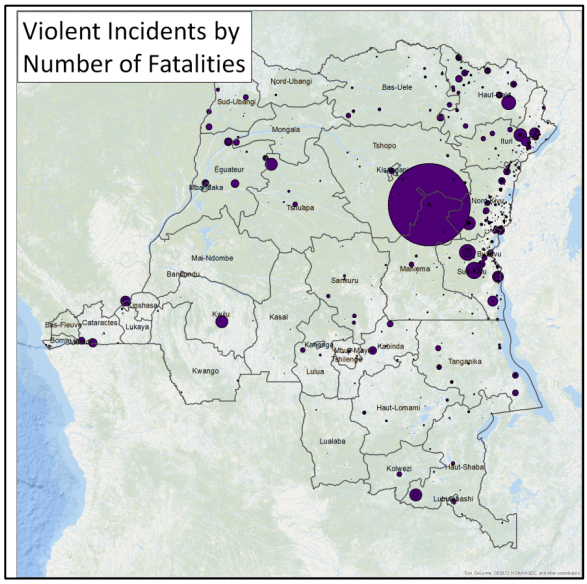

Figure 5: Map of violent incidents with 10+ deaths in the DRC, scaled by number of deaths

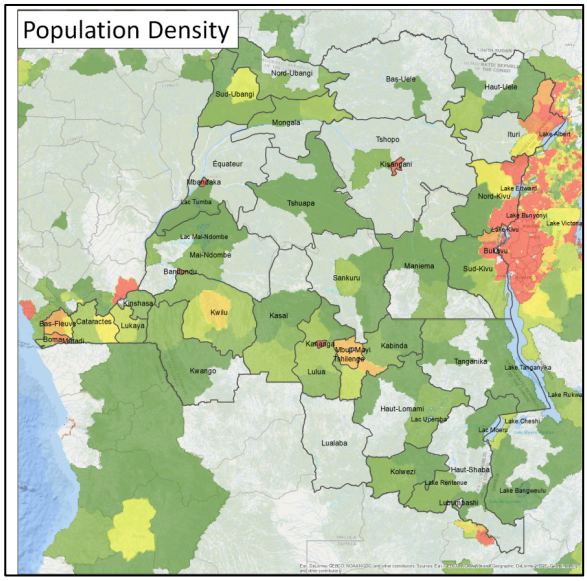

Figure 6: Population density of the DRC and surrounding area

Environmental Security

Geologic and climactic processes in and around Lake Kivu create a duality of potential prosperity and peril that affect ecosystem services, resources, and press-pulse events. As discussed in the study area definition, the Kivus' soil and climate allow for excellent agricultural production. This capacity represents provisioning services in the volatility model. Lake Kivu itself serves as a cultural icon and supports the ecosystem, resulting in a strong overall ecosystem services component. Environmental strength, though, is being degraded by presses and is at risk of pulse events.

Some of the same geographic features that make Lake Kivu so attractive pose serious threats to the two million inhabitants of its banks. Volcanic activity over long periods of time created mineral deposits in the Kivus, but also built up a large bubble of methane gas under Lake Kivu (Doevenspeck, 2007; Schmid, Halbwachs, and Wehrli, 2004). Lake Kivu's current predicament is eerily similar to that of Lake Nyos, Cameroon, in which carbon dioxide asphyxiated thousands of people on its banks (Kerr, 1987; Weisburd, 1985). This bubble is a potential pulse event on a scale unforeseen from this type of threat. If this gas is triggered by volcanic or seismic activity, or any other mechanism, it would greatly affect ecosystem services around Lake Kivu by killing all life on its banks. A gas eruption would also place a huge strain on the social component of the model, most likely bringing foreign actors to the affected area for aid. Likewise, a pulse of this magnitude would disrupt resource infrastructure and divert efforts to humanitarian causes.

Another potential pulse event is Kivu's volcano itself, Mount Nyiragongo, which erupts regularly (See Figure 7). Its last major eruption was in 2002, and much of central Goma was destroyed. Streams of lava reaching 60km/h flowed into the roads, killing "45 people in the first 24 hours" (BBC Nyiragongo, 2014). This is a clear example of a recent pulse event. It impacted the Kivus socially by displacing

350,000 people who required aid (Ibid). The 2002 eruption fortunately did not disturb Lake Kivu's gas bubble, but future volcanic activity could trigger its eruption, combining the effects of the two pulse events.

More positively, Great Rift Valley's volcanic processes have created rich streaks of coltan and gold running through the rolling hills of North and South Kivu. Other minerals are present throughout the country, though these two are the most prevalent in the eastern regions (See Figure 8) (Tervuren, 2005).

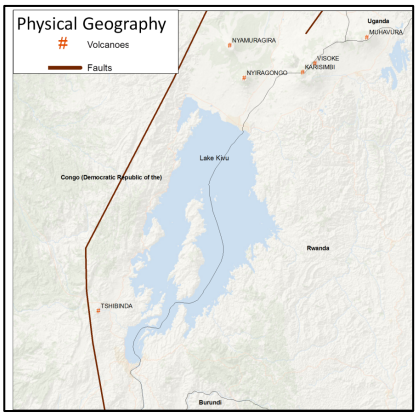

Figure 7: Map of volcanoes and faults surrounding Lake Kivu

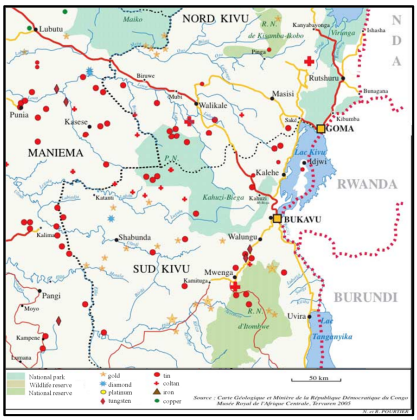

Figure 8: Map of resources in North and South Kivu (Tervuren, 2005)

Each metal has different uses, is located in different regions, and is controlled by different entities (Schmidt-Eisenlohr, 1978). This strengthens the resources factor immensely, giving the region vast quantities of primary sector wealth. However, control of these resources often sparks conflict among militant groups, threatening the environmental security of the entire region.

Well Being

Institutional corruption and geographic threats on a system level negatively affect individual well-being. Most of the 5 million people who died during the First and Second Congo Wars were not killed in firefights, but by being exposed to the elements after displacement (Stearns, 2012). This is a clear example of governmental actions, which sparked the conflicts, adversely affecting the local population. A second way that societal factors and conflict are degrading individual well-being is the widespread use of rape as a weapon by the Congolese army and other militant groups (Sawyer, 2014). Psychological trauma from these horrific incidents last for years, and sometimes the rest of the victims' lives. While organizations such as the Maison Marguerite provide aid and shelter to victims (Ibid.), the problem is still rampant in the Kivu provinces.

Geographic presses lower individual well-being over long periods of time, while a pulse event could completely devastate the population. Lack of governmental regulation allows for presses such as deforestation to go unchecked, which is an unsustainable source of fuel. Forests are also being cleared for illicit mining activity (IES, 2008). This clearly shows the connection between inadequate social factors, resources, and physical geographical presses. Secondly, the eruption of

Mount Nyiragongo in 2002 and the DRC's response to it shows how devastating a pulse event can be (BBC Nyiragongo, 2014). The well-being of the 2 million people living on the banks of Lake Kivu is at risk of the complex pulse events posed by the active volcano and Limnic Lake in their proximity.

Results and Conclusion

Lake Kivu and the surrounding region is one of the most volatile areas in the world, and deserves further examination. Geographically, the land immediately surrounding the lake is among the wealthiest on earth, but tragically this is not the case. Two models (with and without conflict) for understanding the complexity of the eastern DRC were introduced, each split into four quadrants. The lack of governance in the Kivu provinces has made the region vulnerable to militant groups extracting resources to further their organizations. This extraction is motivated by illegal mineral trade across the Ugandan and Rwandan border to supply the world economy with rare earth metals. Political and social problems are compounded by geographic presses and pulses, which constantly threaten the region. All of these factors work against individual well being in the Kivus, making what could be a prosperous region very dangerous.

Future research will work to quantify the Kivu Volatility Model with conflict. Each factor will be measured on a numeric scale, and relationships between factors will also be quantified through equations weighted on the strength of the relationship. When the model is quantified, it is expected to show social factors and external drivers as the two most important contributors to conflict. Once validated, these results could influence policy both within the DRC and in advising international organizations giving aid. The Kivu provinces will continue to be a hot spot of violence and lawlessness until the international community gives it the deserved attention, and this model can serve as a tool moving forward.

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