CENTER FOR NATION RECONSTRUCTION AND CAPACITY DEVELOPMENT
United States Military Academy
West Point, New York 10996

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Methodology to Model and Understand the Complexities of Social, Economic, and Governance Interactions for Regional Assessment in Kenya

Prepared By
Cadets Steven Han, Nolan Melson,
Joshua Stephens, Derek Turner, Dr. John V. Farr, and
MAJ Kristin C. Saling
Department of Systems Engineering
United States Military Academy

Prepared For
Construction Engineering Research Laboratory
Engineer Research and Development Center
PO Box 9005
Champaign, IL, 61826-9005

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About Us

The Superintendent of the United States Military Academy (USMA) at West Point officially approved the creation of the Center for Nation Reconstruction and Capacity Development (C/NRCD) on 18 November 2010. Leadership from West Point and the Army realized that the US Army, as an agent of the nation, would continue to grapple with the burden of building partner capacity and nation reconstruction (NR) for the foreseeable future. The Department of Defense (DoD), mainly in support of the civilian agencies charged with leading these complex endeavors, will play a vital role in NR and capacity development (CD) in both pre and post conflict environments. West Point affords the C/NRCD an interdisciplinary perspective making it uniquely postured to develop training, education, and research to support this mission.

The mission for the Center for Nation Reconstruction and Capacity Development (C/NRCD) is to take an interdisciplinary and systems approach in facilitating and focusing research, professional practice, training, and information dissemination in the planning, execution, and assessment of efforts to construct infrastructure, networks, policies, and competencies in support of building partner capacity for communities and nations situated primarily but not solely in developing countries. The Center will have a strong focus on professional practice in support of developing current and future Army leaders through its creation of cultural immersion and research opportunities for both cadets and faculty.

The research program within the C/NRCD directly addresses specific Academy needs:

• Research enriches cadet education, reinforcing the West Point Leader Development Systems through meaningful high impact practices. Cadets learn best when they are challenged and when they are interested. The introduction of current issues facing the military into their curriculum achieves both.

• Research enhances professional development opportunities for our faculty. It is important to develop and grow as a professional officer in each assignment along with our permanent faculty.

• Research maintains strong ties between the USMA and Army/DoD agencies. The USMA is a tremendous source of highly qualified analysts for the Army and DoD.

• Research provides for the integration of new technologies. As the pace of technological advances increases, the Academy's education program must not only keep pace but must also lead to ensure our graduates and junior officers are prepared for their continued service to the Army.

• Research enhances the capabilities of the Army and DoD. The client-based component of the C/NRCD research program focuses on challenging problems that these client organizations are struggling to solve with their own resources. In some cases, USMA personnel have key skills and talent that enable solutions to these problems. In many cases, USMA personnel simply contribute to the effort applied to these problems.

For more information please contact:

Center for Nation Reconstruction and Capacity Development
Attn: Dr. John Farr, Director
Department of Systems Engineering
Mahan Hall, Bldg. 752
West Point, NY 10996
John.Farr@usma.edu
845-938-5206

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Abstract

This research explores the use of complex systems techniques to understand, model, and quantify how local events in the areas of security, governance, and economic development can have far-reaching regional impacts in developing countries. In support of U.S. Africa Command (AFRICOM) and the Engineering Research and Development Center (ERDC) of the U.S. Army Corps of Engineers, these techniques were used to develop an assessment tool to study these impacts across different regions in Africa, with a central point of interest in Kenya.

Several systems diagramming and system dynamics techniques were explored to conduct a thorough system analysis and ultimately determine what inputs cause the largest increase in key state variables representing a country's capacity and status. The resulting model will be used by AFRICOM analysts to determine the effect of local events across a wide range of variables in order to determine where the largest impact can be made to the improvement of a country's economic, social, and security status, and thereby prioritize investment and other activities in the area of interest.

The research was conducted under the guise of the Cultural Reasoning and Ethnographic Analysis for the Tactical Environment in support of the ERDC. This effort will provide knowledge, methods, and computational tools to inform planning for civil-military operations.

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Chapter 1
Introduction

1.1 Problem Statement

Researchers in U.S. Africa Command (AFRICOM) and the Engineering Research and Development Center (ERDC) of the U.S. Army Corps of Engineers, approaching the problem of assessment and investment strategy in Africa, have realized that there is a "butterfly effect[1]," the far-reaching impacts of deceptively minor local events across far regions in Africa. If an event occurs in one locality, how does it affect another? Can we quantify the effects? Do small changes in the area of local security affect the larger regional or national economy?

This research explored these questions through the use of complex systems techniques such as systems diagramming and system dynamics to simulate and thereby better understand the impact of local events across different regions. Using system of systems (SoS) methods, processes, and tolls (MPTs), we identified and evaluated the most influential inputs in the broad categories of economics, security, essential services, and government services. We then evaluated their effects on variables indicating the capacity of the region: the amount of essential services, the security of the region, the economics of the area, and government legitimacy. Ultimately, the users of this methodology will be able to determine which inputs cause the highest increase to overall country capacity in order to help prioritize investment and other activities in a given area of interest.

1.2 Why is Africa Of Strategic Importance To The United States and What Is The Role Of Complex Systems In Providing Insight Into Their Behavior?

According to the International Foundation for Education and Self Help, Africa is one of the largest and most important battlegrounds in the fight against terrorism. Years before the 9/11 attacks, terrorists attacked U.S. embassies and Al Qaeda leader Osama bin Laden began his operations in the Sudan, an area that is still highly unstable. Africa is also a major battleground in another critical fight, the fight against HIV/AIDS, which has left millions of children without their parents and susceptible to terrorist organizational coercion. Al-Shabaab is a prime example of a terrorist organization that has emerged in the region. Backed by Al Quaeda and based primarily out of Somalia, Al-Shabaab has a growing presence throughout the Horn of Africa. According to Shinn (2009):

"Al-Shabaab recruits though a process of de-socialization. It targets children in Islamic educational institutions who are orphans or removed from their families. They undergo intensive indoctrination usually in isolated circumstances. This methodology allows al-Shabaab to blur clan lines in its recruitment. It has attracted leaders and supporters from Somaliland and Puntland as well as central and southern Somalia. No single clan prevails in the organization but some clans seem more attracted to al-Shabaab than others."

Gilbert Khadiagala's special report, *Terrorism in the Horn of Africa,* for the United States Institute for Peace (USIP) proposes further evidence of Al Qaeda's influence within the Horn: he argues that Al Qaeda cells have operated for some time throughout the Horn and East Africa, undetected by the region's intelligence units. He cites the attack of the Israeli-owned Paradise Hotel in Mombassa, Kenya, in November 2002 and the simultaneous attempt to bring down a plane full of Israeli tourists with a surface to air missile as evidence of Al Qaeda presence. According to Khadiagala, "this drove home the urgency to the governments of the Horn, East Africa, and the U.S. of stepping up the development of the capacity to effectively combat terror in the region." Khadiagala concludes that the attempt on Israeli tourists in Mombasa further demonstrated how the Horn has become "the site for the proxy battles between the U.S., its allies, and its new enemies."

The availability of limited resources has also become a point of contention. The Horn of Africa is becoming as important as the Middle East as a source of oil and natural gas. China, India, Europe, the United States, Iran, and others are all competing for access to these and other energy and mineral resources in the region. According to the online international magazine *Defense Update,* Iran's mineral and resource interests coincide with a property bid in the region that threatens to further destabilize both the Horn of Africa nations and their neighbors still further. *Defense Update* also alleges that Iran is already providing secret support to the Islamic Courts Union in Somalia in order to gain access to their uranium deposits.

We can see the interaction of economic elements such as natural resources, social variables such as health, and security variables such as terrorist activity and destabilization in Africa just by looking at a brief overview of Africa's current issues. The complex systems approach further develops these interactions into relationships and then to mathematical functions. This methodology enables us to not only see what relationships exist but to measure and quantify these effects.

1.3 Solution Methodology

The complex systems/SoS[1] approach we use is based off an analysis of Africa by regions, not nations or states. We differentiate these because of the latent artificiality of national borders in Africa; terrorist influence, tribal influence, climate influence, and other key influences do not follow national borders. The understanding of the region is highly dependent on a holistic approach because of these influences.

While we focus on regions to construct the methodology, we will center the study around Kenya. Kenya is of particular importance to the U.S. because shares borders with many countries exhibiting signs of emerging terrorist organizations, and currently acts as a buffer country between these relatively unstable countries. Kenya faces many destabilizing factors, including its declining tourism-based economy and its predominantly non-Muslim population surrounded by many predominantly Muslim countries. Boko Haram trained terrorists, Al-Shabaad incursions, and other religious and ethnic attacks have all contributed to instability within the country. The number of interfering factors in the region make it extremely complex to analyze, assess, and determine where to apply investment or action to stabilize the region.

Ultimately, this analysis will deconstruct Kenya in order to make these points of application apparent. Within this analysis, we construct systemigrams, stock and flow charts, system dynamics (SD) models, and causal loop diagrams (CLDs) which better demonstrate the interaction and interdependencies of these factors and quantify the effect that changing each of these factors can have throughout the region.

1.4 Summary

This research is unique in that it utilizes complex systems MPTs coupled with social science research to identify socio-cultural dynamics relevant to national policy and investments. With refinement, these MPTs can be used for strategic investments and national policy decisions that can maximize return on investment on many levels. It develops a framework for employing sound analytics to support investment strategies on a regional/national basis, and demonstrates how these social-cultural dynamics and synergies of military, social, and economic decisions can indicate best practices in international policy.

Chapter 2
Literature Review

2.1 Introduction

Within the discipline of complex systems[1] analysis, there are multiple tools used in order to analyze complex problems with multiple interdependent variables. The tools selected for this particular problem are systemigrams, causal loop diagrams, and stock and flow diagrams. Systemigrams and causal loop diagrams are typically non-quantitative in nature and are mainly used to demonstrate interdependencies, relationships, and causality between variables. Stock and flow diagrams integrate a quantitative element that better demonstrates just how related the variables in question are.

2.2 Complex Systems Techniques

The discipline known as "system engineering" has evolved greatly as new processes have been developed for understanding and building large complex systems. The challenges that systems engineers face with this today involve connecting the systems properly into a system of systems (SoS) configuration that shows the proper interactions without huge propagation of error. This activity has not been classified as a separate practice, although complexity systems are clearly defined as a sub-discipline in the area of mathematics.

There are two perspectives for looking at a complex system that come from the discipline: one that focuses on "connecting the parts" and one that focuses on capabilities. This research focuses on "connecting the parts." This best suits the research objective of modeling and better understanding the interaction of the systems, as we do not currently have a specific problem or capability in the region to address. This perspective recognizes that the complex systems model is built from a collection of operating systems, and works to identify, develop, and verify the interconnection of these systems.

In this system it is essential to identify the sub-systems that contribute to the capacity of a nation state and its ability to provide a safe and secure environment, a stable government, essential services, and a healthy economy. Trying to categorize the complex interactions that comprise a nation presents a set of unique challenges. We must categorize and relate the dependencies of economic, security, and governance variables with both internal (religious and ethnic tensions, government policy, efficiency, etc.) and external factors (investments, regional events, military actions, etc.). This effort takes place in three steps: 1) describe the problem in a way that leads to understanding of its characteristics, 2) diagramming tools that lead to understanding the interactions and dependencies, and 3) systems dynamics (SD) modeling to understand its behavior quantitatively.

To begin categorizing a nation state as a complex system, we draw on the work of Ireland and White (2011) and Sheard and Mostashari (2008), compared in Table 2.1. The elements that comprise the nation state's efforts in each of these areas by themselves can be considered some level of a system, and the interactions of these clearly fit both definitions of a complex system.

Table 2.1 *Complex systems behaviors (from Farr et al, 2013)*

Sheard and Mostashari (2008)	Ireland and White (2011)	Nation State System Behavior
1. Autonomous interacting parts (agents)		The elements are heterogeneous, with building blocks (agencies, processes, external stimuli, etc.) that are individual agents of the systems.
- Fuzzy Boundaries	Exhibits tight and loose couplings	Interactions vary dynamically with boundaries (responsibilities and products) that are often ill defined.
2. Self-organizing	Self organized	Nation states are continuously realigned based upon the affinity of the elements (leaders, organization, elected officials, etc.).
- Energy in and out	Thrives on diversity	Nation states exist and function based upon intricate and multifarious interrelationships.
3. Display emergent macro level behavior		Nation states are social institutions with structure not tied to human bodies.
- Nonlinearity		Investments in security, governance, and economic development often do not translate directly to improved living conditions or a countries' capacity to develop basic services.
- Nonhierarchy and central authority	Many factors at play	No one group understands all of the activities or rational behind its mission yet typically government is controlled by a central authority. Identifying and building common ground is necessary for progress.
- Various scales	Sensitive to small effects	Processes and activities exist at all levels. Small changes at most levels can lead to significant changes in a nation state.
4. Adapt to surroundings (environment)	Internal and external relationships are key	Governments continue to adapt to leadership, external stimuli, and a host of other events either locally or at the global level. Internal and external relationships are the enablers of change.
- Become more complex with time; increasingly specialized	Evolves on its own as a whole	Ideally a nation state evolves with the social-technical aspects of the global market and security environment. Elements or the complex system as a whole can evolve.
- Elements change in response to pressures from neighboring elements	Ever changing	Processes, products, people, etc., continue to evolve. Most nation sates have no status quo otherwise that cannot serve the basic needs of its people.
	Acts robustly	A healthy nation state can survive significant changes in environmental events (natural or manmade events) and still perform basic functions.
	Stimulates different perspectives	New ideas continually evolve from normally the democratic process. Government and country capacity must adopt to the social/technical/economic realities of the 21st century.
	Informs the observer	Often external intervention is required for governments to meet the needs of its people. Internal stakeholders often do not understand what must be done to improvement government.
	Performs openly	Transparent government is one of the key tenets of democracy. All stakeholders typically know internal and external outcomes.
	Surprising emergence	Behavior, at all levels, is often unexpected. Religion, history, etc., are often not indicators of future behavior.

In many respects a nation state is the ultimate complex system. As shown in Figure 2.1., countries exhibit all the behavior of a complex system: they evolve, they self organize, they are resilient, they are flexible, and so forth. They are unpredictable and cannot be completely controlled. This makes modeling the nation state as a complex system challenging, but possible using complex systems/SoS MTPs.

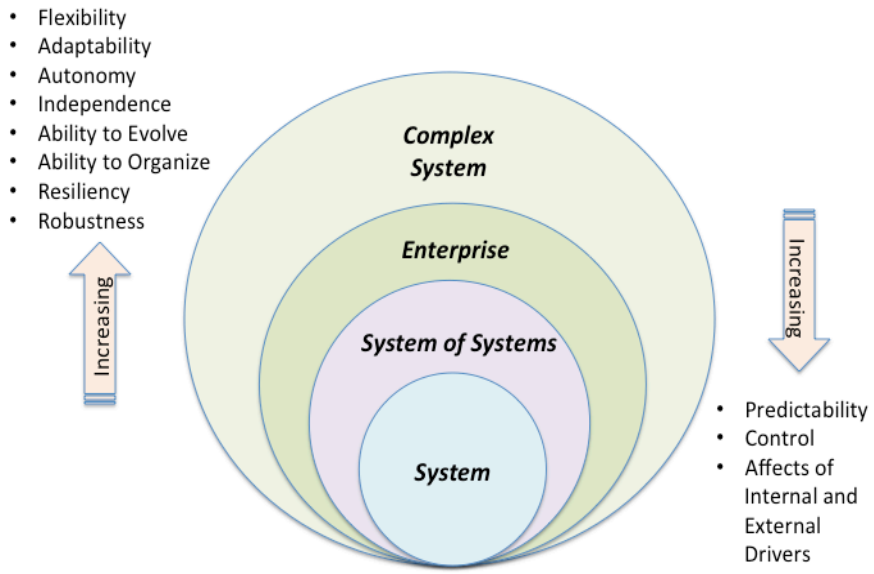

Figure 2.1 *Venn relationship among system types showing attributes as a function of hierarchy modified from (White 2011)*

Some work has already been done on qualifying and quantifying a nation state as a complex system. Understanding, quantifying, and building predictive tools for building partner capacity (BPC) is complex and not necessarily well understood, but some work has already been done to develop the areas of governance, security, and economy in terms of nation state behavior as complex systems. We use those as building blocks to start building our model.

2.3 Building Partner Capacity

The end to the wars in Afghanistan and Iraq do not mean an end to U.S. responsibility or interest in building partner capacity (BPC). “The greatest threats to our national security will continue to come from both emerging ambitious actors/states and from nations unable or unwilling to meet the basic needs and aspirations of their people” (Department of the Army, 2008). Since the end of the Cold War, the U.S. has begun new stability and reconstruction (S&R) operations every 18 to 24 months, with increasing challenges to these efforts. Military enterprise is not only concerned with basic government stability, but with robust economy, democracy and fair elections, human rights, and growth to a respected member of the international community. These efforts come with significant price tags in terms of human life and investments, and we do not yet understand how to efficiently and effectively invest our resources.

As depicted in Figure 2.2, we must better understand when to invest in building host nation capacity, in bottom-driven small projects, in top-driven large projects, and how the payoff for specific investments in governance, economic, and security efforts affects the other areas. This is critical to the current U.S. philosophy regarding application of military and industrial power, and with proper application, early in Figure 2.2.’s non-intervention stage, proper application could reduce or prevent the emergence of non-state actors and improve quality of life and capacity quickly enough to prevent the outbreak of hostility.

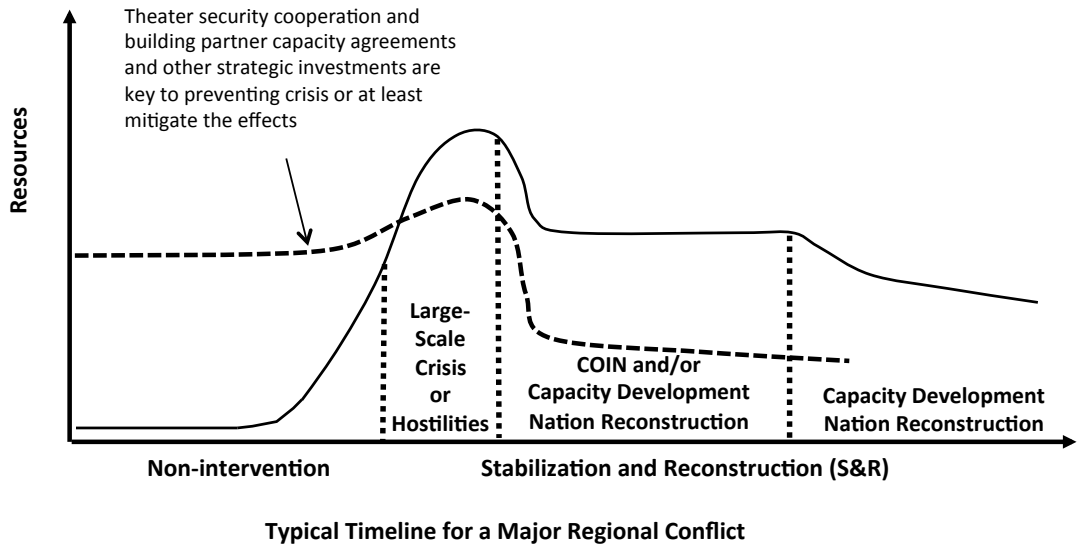

Figure 2.2 *Timeline as a function of resources for military intervention – the military interaction lifecycle*

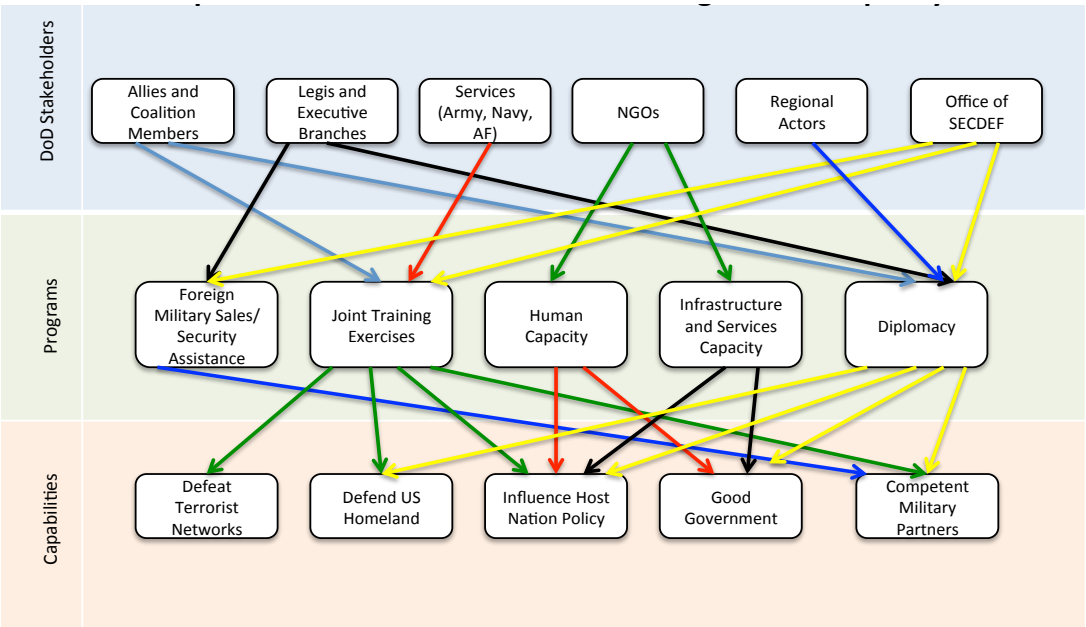

Figure 2.3 *Stakeholders, programs, and capabilities swim lane chart for building partner capacity*

2.4 Actors and Capabilities Swim Chart for DoD Building Partner Capacity

Many researchers and SoS analysts utilize swim lane charts to understand SoS relationships. According to *Microsoft Visio™,* a swim lane chart is a visual element used in many types of process flow diagrams. These are charts that visually distinguish responsibilities for sub-processes of a business process. Swim lanes can be horizontal, vertical, or divided up into sectors (i.e. customer sales, contracts, input, resources, etc). Additionally, according to *Agile Modeling,* swim lanes are often used in manufacturing processes to better clarify the process layout and to optimize floor capacity, efficiency, output, and ultimately, lean operations. In relation to nation building, swim lane charts are an efficient way to see relationships between stakeholders, programs, capabilities, inputs, and resources without overwhelming the resources with detailed processes.

When analyzing the swim lane chart in Figure 2.3, observe all of the DoD stakeholders involved in building partner capacity: allies and coalition members, legislative and executive branches, services (Army, Navy, Air Force), NGOs, regional actors, and the Office of the Secretary of Defense (OSD). Analyzing allies and coalition members from the chart, we can see that their programs consist of joint training exercises, a program that has an effect on the U.S. capability to defeat terrorist networks, defend homeland, influence host nation policy, and establish competent military partners. Allies and coalition members also affect the program of diplomacy comprised of these same capabilities. When analyzing the programs that the military services stakeholder affects, the joint training exercise program is the only program affected by this stakeholder. Similarly limited stakeholders are NGOs, which only tend to affect human capacity with the capability to influence host nation policy, and infrastructure and services capacity, which has the capability to establish good government.

From our swim lane chart, we were able to draw other correlations between the effects of DoD stakeholders on building capacity programs and what capabilities in the government and society that these programs could affect, broadening our understanding of their relationships.

Even without early intervention, we must be able to plan and resource throughout the conflict life cycle shown in Figure 2.2. Each phase requires a different focus and investment in security, governance, and economic development projects. “The very rapid defeat of the enemy military means the U.S. must be ready to field the resources needed to secure stability and begin the reconstruction process promptly—ideally concurrently—with the end of major combat. This can only be done if planning for the stabilization and reconstruction operations is integrated into planning for the conflict from the beginning and if the right skills are in the theater to begin their operations concurrently with the surrender or collapse of the enemy military” (Binnendijk and Johnson, 2003). The complex, adaptive environment our military faces today requires an understanding of the conditions that exist in the partner nation in order to make smart investments in capacity development. The social, governance, and economic implications of these investments within the partner country and the resulting effects can often lead to unforeseen second order effects. These second order effects are hard to predict, difficult to model, and almost impossible to quantify. Still, quantitative means are needed for not only prioritizing investments but to understand the short and long-term effects of those investments.

Formal systems engineering MPTs provide us with the capability to not only capture the interactions but to quantify the investments. By applying these MPTs that we can 1) better plan for these types of investments as part of the campaign planning process, 2) better understand where and when to allocate resources in the governance, social, and economic domains, and 3) ultimately save lives by affecting the desired the change. Little quantitative support exists in how to allocate resources in support of BPC and a countries capacity to provide for its populace along with a fundamental understanding of how country capacity is affected by economic, security, and governance investment. Systems thinking tools and characterizations are key to help understand the interdependencies of the various agencies, actors, products, constraints, etc., that can affects a countries capacity.

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Chapter 3
Model Development

3.1 Methodology

The methodology used in this research was based on a purely iterative process that leverages feedback from the stakeholder and opens channels of communication throughout the entirety of the research. Initially, the problem statement was very open; we investigated the level of aggregation that we wanted to use, the level of depth of our focus, and the layers of country capacity that were to comprise our analysis. Once we obtained feedback from the stakeholders and refined our focus to Kenya and the Horn of Africa, we conducted extensive research on Kenya and the surrounding nations in order to get a better understanding of all the possible factors (history, economy, social issues, security, political issues, cultural issues) that could impact the region of interest. Ultimately, we created qualitative models to describe the relationship between these factors.

Once we understood the relationships between layers and variables within the layers, we simultaneously created systemigrams, causal loops, and a swim lane chart (i.e., systems diagraming methods) to better understand the interdependencies. This process is shown in Figure 3.1. The systemigrams provided a model demonstrating interdependencies between variables via the usage of action words on arcs. The causal loop diagrams were leveraged to show polarity between variables in the five individual layers and identified feedback and reinforcing loops. Lastly, the swim lane chart identified the key stakeholders in the analysis, the specific programs that comprised the stakeholders, the capabilities of each program and ultimately how all three layers are linked. These qualitative models were revised multiple times as the research evolved and new factors were explored.

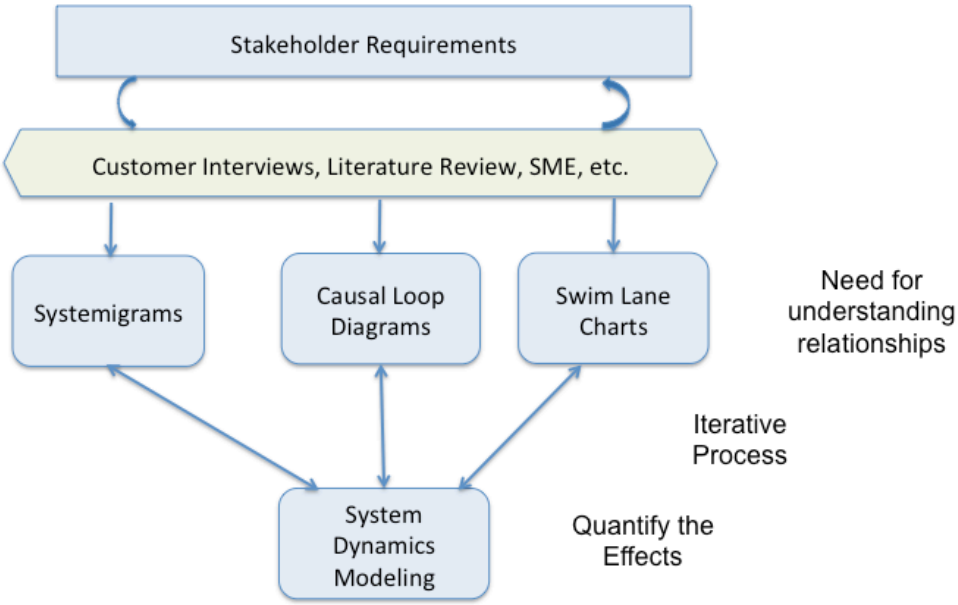

Figure 3.1 *MPTs used to develop complex systems model*

The SD model is the last model stage of research. We created a separate SD model for each layer to identify and explore the interdependencies between variables through the usage of ratios, equations, and implementation of key relationships. All layers are ultimately linked into one SD model that is able to run and output the system's behavior.

3.2 System of Systems Diagramming Techniques

Causal Loop Diagramming

Much of the art in SD is being able to represent a complex structure using various quantitative and qualitative means. A useful approach is using feedback loops to show interdependencies between the variables that define a system. When these feedback loops are combined, it creates a visual qualitative measure known as a causal loop diagram (CLD). This is a map showing the causal links among the variables with arrows from a cause to an effect. Causal loop main benefits include: quickly capturing the hypothesis about the causes of dynamics, eliciting and capturing the mental models of individuals or teams, and communicating the important feedbacks that are believed to be responsible for a problem (Sterman, 2006).

The key concepts to understanding a CLD include the polarity of the arrows and the overall feedback loop's polarity. When connecting variables using an arrow, the arrow will have a positive or negative head in direct relation to its effect on the variable it influences. A very basic version can be seen in Figure 3.2., where we have two variables that influence one another, a chicken and an egg. The positive polarity on the arrows show that as the number of eggs increases, so do the chickens, and as the number of chickens increase, so too do the eggs. The overall polarity of the total loop is either a reinforcing loop (positive) or a balancing (negative) loop to the overall system; the chicken and egg loop is reinforcing, as both result in increases to the system with nothing to inhibit the positive growth.

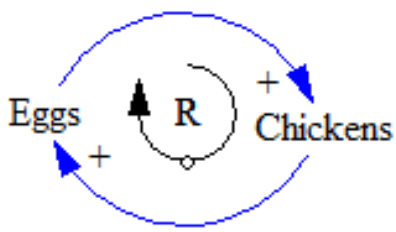

Figure 3.2 *Reinforcing loop*

In contrast to the positive reinforcing loop is the balancing loop seen in Figure 3.3. In this example a road crossing variable is added to the system to regulate the number of chickens. As the chicken capacity increases, more road crossings will be attempted. As more road crossings are attempted, the road will decrease the number of chickens. This overall loop has a balancing (negative) affect to the number of chickens in the system.

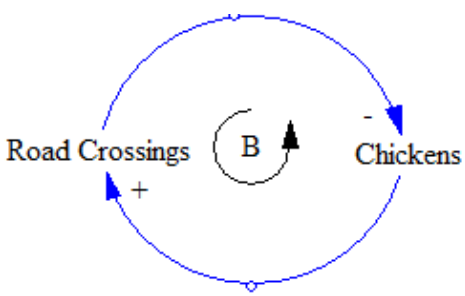

Figure 3.3 *Balancing loop*

The overall causal loop diagram showing the interactions in the system of the chicken population carrying capacity is displayed in Figure 3.4.

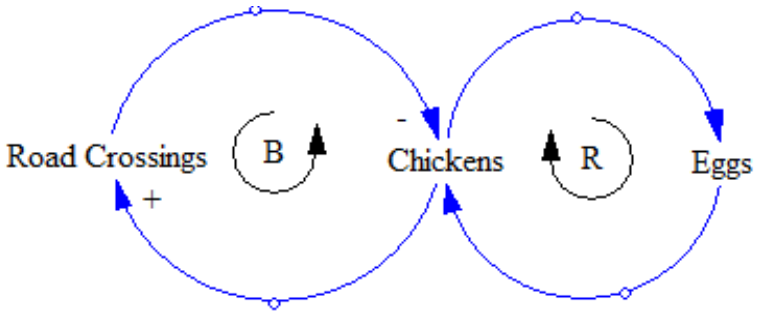

Figure 3.4 *Causal loop diagram*

Causal loop diagrams are useful to qualitatively display the interdependencies of variables in a system. They do not have limits to the number of variables or loop structures that can be displayed. They are useful in quickly capturing the problem, and are an easy tool for communication purposes.

The next step in the solution formulation process is to transform this information and transition it into a stock and flow diagram for quantitative output, but first we had to better understand the variables and their interaction in the system. For that, we used systemigrams.

Systemigrams

Professor John Boardman, pioneer of the systemic diagrams, better known as "systemigrams," developed this model in the late 1980's. According to (Boardman & Sauser, 2008) for the past twenty years "we are still convinced that these same types of integration continue to impact us, interdependently, and little wisdom seems to have been received in the interim to distinguish between them, let alone solve them, a meta-integration problem that emphasizes the complexities we confront." Systemigrams have a multitude of uses in business, transportation, military operations, and just about any topic matter that requires graphical representations of system's sub-systems and their interdependencies.

The evolution of systemigrams may be considered in three phases according to Boardman: "its development as a form of visual language, its adaptation as a methodology for business architecting, and its refinement as an appreciative learning system. In Phase 1, development of the technique concentrated on the graphical portrayal of structured prose" (Blair, Boardman, & Sauser, 2007). Boardman also notes that there are other diagrams in academia that capture interdependent concepts such as concept diagrams, concept mapping, fishbone diagrams, influence diagrams, and even the original flow charts. However, what differentiates these diagrams from systemigrams is that these other diagrams are:

"Largely memory less, capturing the immediacy of prose but then forgetting and moving on to the next local piece of knowledge, making it more difficult to find longer thought threads since they concentrate on linear thinking rather than holistic thinking."

Ultimately, systemigrams were intended to convey a synergy of prose and pictures, embodying the best features of each.

It is critical to note that the systemigram must be correlated to the text that it represents, "recovery of the original prose by inspection of the diagram a key requirement." Those requirements are:

Rules for Prose

1. Address strategic intent, not procedural tactics.
2. Be well-crafted, searching the mind of reader and author.
3. Facilitation and dialogue with stakeholders (owner/originator of strategic intent) may be required to create structured text.

4. Length variable but less than 2000 words; scope of prose must fit scope of resulting systemigram.

Rules for Graphic
1. Required entities are nodes, links, inputs, outputs, beginning, and end.
2. Sized for a single page.
3. Nodes represent key concepts, noun phrases specifying people, organizations, groups, artifacts, and conditions.
4. Links represent relationships and flow between nodes, verb phrases (occasional prepositional phrases) indicating transformation, belonging, and being.
5. Nodes may contain other nodes (to indicate break-out of a document or an organizational/product/process structure.
6. For clarity, the systemigram should contain no crossover of links.
7. Based on experience, to maintain reasonable size for presentation purposes, the ratio of nodes to links should be approximately 1.5.
8. Main flow of systemigram is from top left to bottom right.
9. Geography of systemigram may be exploited to elucidate the "why," "what," "how" in order to validate the Transformational aspect of the systemic model.
10. Color may be used to draw attention to subfamilies of concepts and transformations" (Blair, Boardman, & Sauser, 2007).

Figure 3.5 below is an example systemigram "network enabled capability across all of defense, aimed at producing agile military and nonmilitary effects via a network of networks"

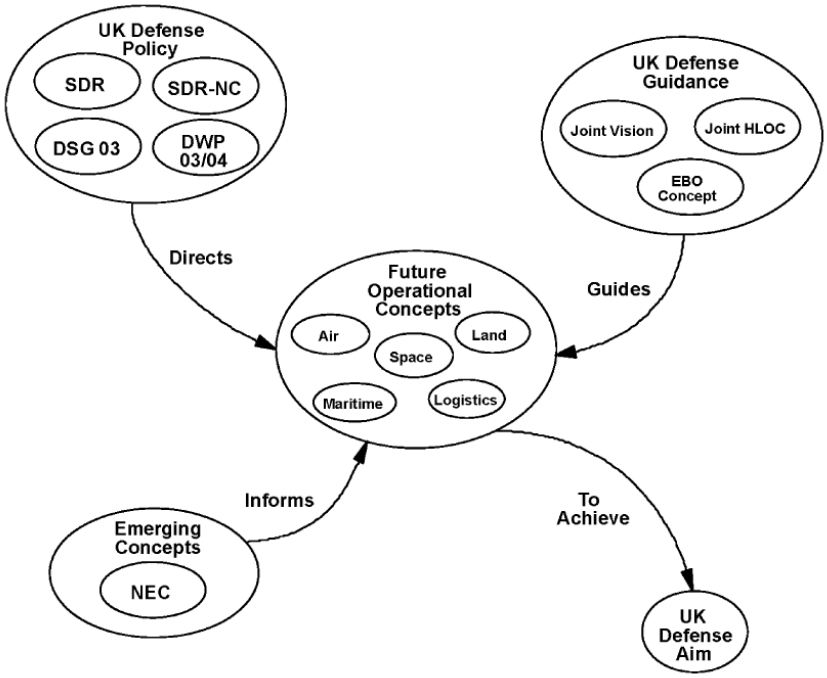

Figure 3.5 *Example systemigram (from Blair et al, 2007)*

In conclusion, systemigrams can be used to analyze interdependencies and relationships in order to tackle issues such as COIN in Afghanistan, narcotics trafficking in Mexico, complex commuter rail systems, and nuclear weapons proliferation. Systemigrams provide us with "a basis for systems architecting, in terms of both enterprise integration (reliant on business process architecting) and technology systems development (reliant on requirements management)" (Boardman & Sauser, 2008). Ultimately, whether you detest systemigrams for their resemblance to a bowl of spaghetti and meatballs

or love them for their holistic representation of interdependencies and relationships, systemigrams are a graphically thorough way of demonstrating the flow of sub-systems throughout a system.

3.3 Systems Dynamics

Transforming the relationships discovered through systems diagramming into a quantitative model can be done with system dynamics techniques. This methodology has seen significant use in determining policy effects on the fight against Middle Eastern terrorist groups and explaining regional development in regions under water resource constraints. With modification, it can be applied to much larger regions of influence and, as we attempt through this research, large portions of Africa.

Research done by Gil et al (2005) not only provides useful insight into the propagation of terrorism but provides a demonstration of SD analysis in solving a problem dealing with regional security. The scope is not broad enough to answer the current problem posed by our stakeholders, but it provides a building block in the further developed model. This study presents information on terrorism in a very strategic pattern. It initially describes the SD process and explanation of graphical behavioral patterns of the output, as shown in figure 3.6. (Gil et al, 2005).

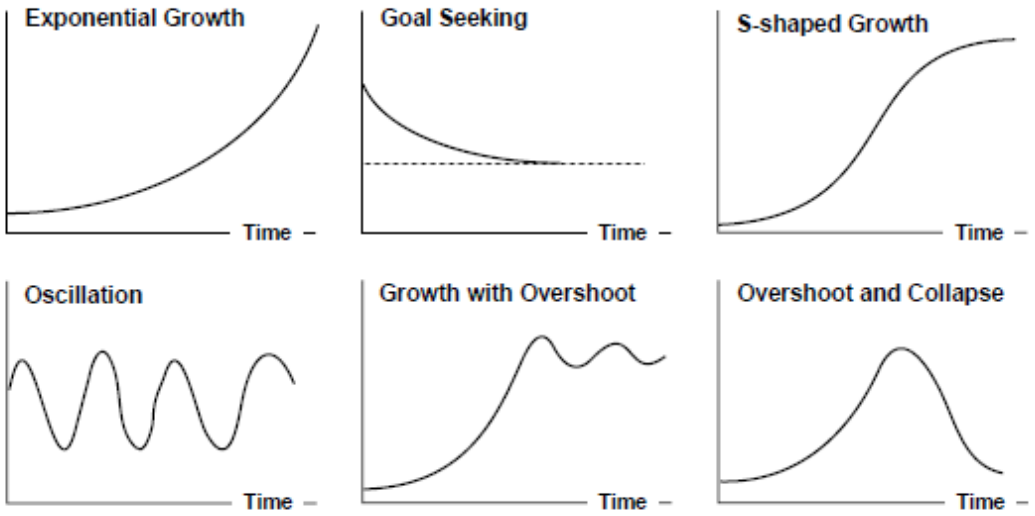

Figure 3.6 *Common modes of behavior in dynamic systems (Sterman, 2000)*

The next step in the SD process taken on the study of policy and terrorism is their use of the CLD to initially show the interaction of variables that influence terrorism, qualitatively. This representation is presented in Figure 3.6 (Gil et al, 2005).

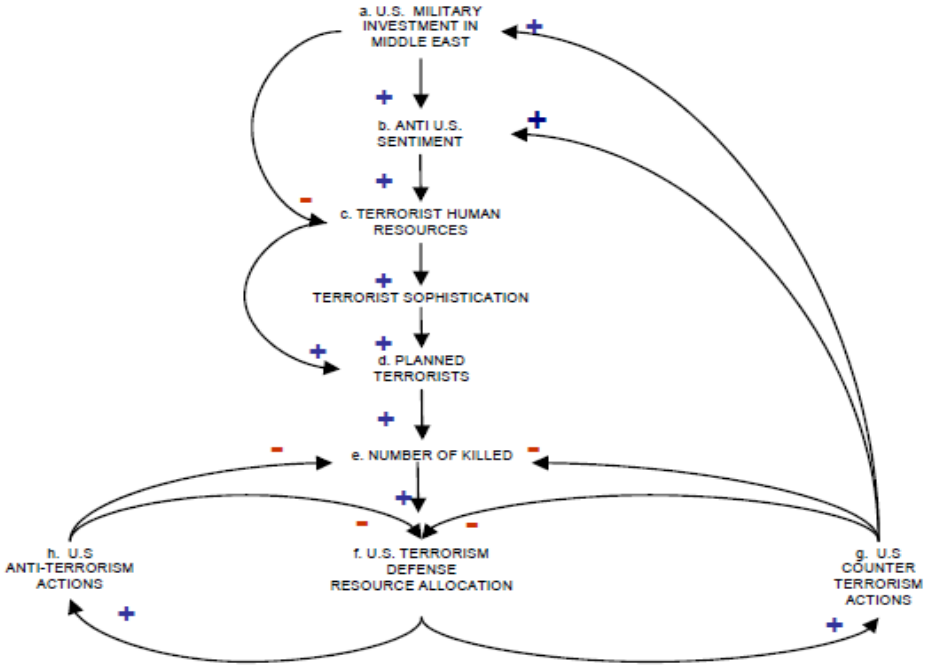

Figure 3.7 *Casual loop diagram of Middle Eastern terrorist group actions against the U.S. (Gil et al, 2005)*

Using modeling software known as Stella®, the study on terrorism was able to take the causal loop shown in Figure 3.7 and turn it into a quantitative diagram known as a stock and flow diagram, which is shown in Figure 3.8. This proves very beneficial for our development of an analysis tool for AFRICOM. The software used for the development of these models in this research is Vensim®[1], which has the same output displaying stocks, flows, and variables that influence the system.

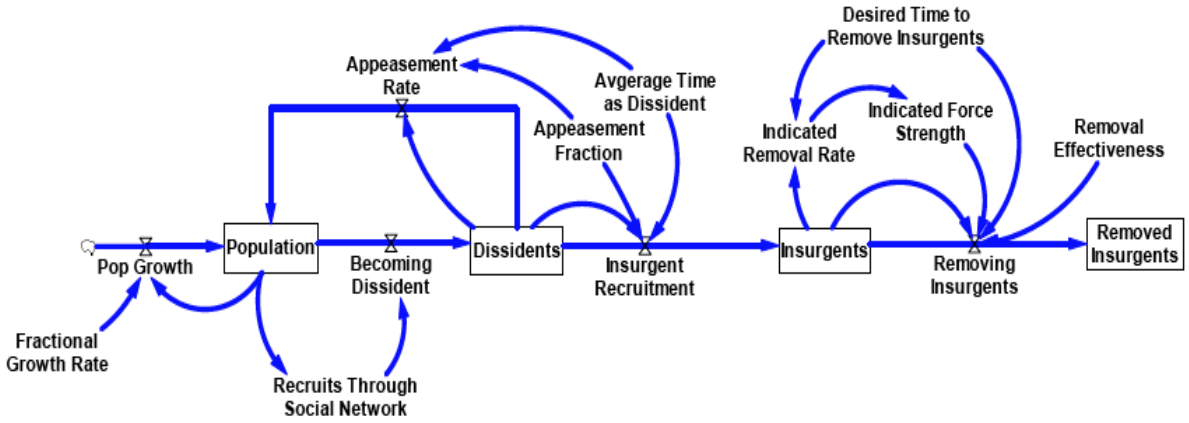

Figure 3.8 *The stock and flow diagram from Stella® (from Choucri, et al, 2006)*

[1] Ventana Systems, Inc. publishes Vensim, which is used for constructing models of business, scientific, environmental, and social systems. Information on Vensim can be found at http://www.vensim.com/

The next step in the process is running the model. It outputs graphs that can be analyzed to determine if common behaviors exists.

Systems dynamics has been used extensively for military problems. Robbins (2005) developed an SD model focused mainly on combat operations. Sterman (2006) presents a model of gross domestic product and economics. Crane (2009) utilized a set of what he termed Nation Building Elements, which consisted of security, humanitarian relief, economic stabilization, and governance to build a conceptual SD model of the Democratic Republic of the Congo. A separate study that deals with a variable of interest to the problem in Africa is a study done by a school in China (Shanshan et al, 2009). The primary variable of study deals with access to water resources in the arid region of the Manas Basin in Africa. It provides an analysis not focused on regional security but on regional development, and gives us another example of SD techniques being used to solve a complex regional problem. Much as our methodology starts, the Shanshan paper begins by developing a causal loop diagram, then breaks down the variable of water into several different sub-systems (Shanshan et al, 2009). The interaction of these sub-systems with the overall system of water and the social and cultural systems forced to interact by this system demonstrates several methods by which a variable can be approached. This shows us that while a relationship may not be found through one approach, other approaches are possible, and one of those may yield a better result. All of these were useful building blocks in the development of our more complex model, which integrates all these factors.

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Chapter 4
Demonstration Study

4.1 Introduction

In order to conduct a demonstration study, we had to create numerous non-numerical models to combine for our final Kenya demonstration project. First, we analyzed the strategic importance of Kenya with regard to security, health, religion, and other strategic components affecting Kenyan society. We then began developing the interaction of these as a system of systems, and developed a building partner capacity swim-lane chart that allowed us to establish a visual representation of the relationships between stakeholders, programs, and capabilities. We also developed systemigrams for the six layers key to our model (Governmental Legitimacy, Security, Economics, Country Capacity, Essential Services, and Water Security). Ultimately, systemigrams provided us with a more in-depth analysis of the interdependencies linking the layers of our model. We developed causal loops for each layer that provided us with positive and negative relationships between variables in our model, which ultimately allowed us to assign numerical values and ratios used in the final SD model created in *Vensim®.*

4.2 Why Kenya Is Of Strategic Importance

We briefly discussed the strategic importance of Kenya, but a more in-depth analysis was necessary to better identify places where the U.S. could apply investment or action to influence stability.

Kenya's status as a stable country is beginning to decline due to a variety of reasons, and if intervention does not occur, it may no longer be considered a country that is sympathetic to the concerns of the U.S. With the recent increase in insurgent activity, Africa has become a battleground in the fight against terrorism. This has resulted in drastic decreases in tourist activity, a critical source of income for Kenya. Kenya, like much of Africa, also faces an increasing problem with AIDS/HIV. This is problematic for the U.S. as well, as Kenya has been one of the key nations aiding the U.S. in the region, serving as a mediator for issues occurring in the area. Kenya played an important role as it mediated the relations in Sudan's north-south separation in February of 2005 (CIA, 2011). Currently, Kenya is home to approximately a quarter million refugees from surrounding countries (CIA, 2011).

Kenya has a population of 41,070,934 people, which is quite large for a country in this area (CIA, 2011). It is neighbored by Somalia, Ethiopia, Uganda, and Tanzania, however, it is important to note that Somalia has had the greatest negative impact in recent years, and is a country consisting of only 9,925,640 people (CIA, 2011). Kenya, like neighboring countries, consists of a relatively young populace, meaning that the impression the U.S. leaves on Kenya's people today may have lasting effects in the future. Approximately 42.2% is under the age of fourteen, 55.1% between fifteen and sixty-four years of age and only 2.7% is over sixty-five (CIA, 2011). Kenya also has a large amount of infrastructure compared to the surrounding areas, with 22% of its population living in urbanized locations (CIA, 2011). Kenya has a very high literacy rate at 85.1%; which is much higher than any surrounding country (CIA, 2011). This is vital when looking into the lifestyle of Kenyan's as it supports the idea that the country focuses on education, and the future of its youth. They also have a fairly high school life expectancy with an average of eleven years per person (CIA, 2011). This impacts the U.S.' decision to intervene in this country because it has the most potential for investors since the population does not need to be used for only unskilled cheap labor, but can instead be used for more complex business ventures.

However, Kenya has an HIV and AIDS rate that is very concerning. 6.3% of the population currently possesses these viruses, ranking Kenya the 11th in the world (CIA, 2011). It is highly probably that the large amount of the population harboring this disease causes the average lifespan of Kenyan's to be as young as short as it is at just under sixty year (CIA, 2011). The high level of HIV and AIDS is an area that may be important for the U.S. to intervene, as it presents a realm of the country's development which is lacking compared to its literacy rate and economy. In order for Kenya to become a fully developed

country, the amount of people possessing this disease must decrease. Furthermore, being ranked 11th globally in regards to HIV and AIDS deters foreign investors from inhabiting this country.

Religion separates Kenya from its neighbors and fosters a healthy climate towards the U.S. since a majority of the population shares similar views. However, religion also poses problems since Kenya is a predominantly Christian country surrounded by mostly Muslim countries. Kenya is 45% Protestant and 33% Roman Catholic, with only 10% of the population being Muslim (CIA, 2011). Somalia on the other hand, is almost entirely Muslim. This often results in conflict between the two neighboring countries. The rest of Kenya's population consists of 10% indigenous beliefs and 2% being classified as other (CIA, 2011). Somalia has a large Radical Islamic movement, most notably Al Shabaab, Al Qaeda in Somalia, which often targets the vastly Christian population of Kenya. However, the Christian population is also more conducive to interaction with the U.S.

The military structure in Kenya is also very similar to that of the U.S. in regards to requirements to join. Kenya has an Army, Air Force, and Navy and is an all-volunteer fighting force (CIA, 2011). The minimum age to join the military is 18, and some of its officers are even trained in American institutions to include West Point. This builds a more cohesive and friendly relationship between the U.S. Military and Kenya's Military. An eight-year term of service is the requirement of enlistment. Kenya's Military is often used to defend the country from terrorist attacks, often stemming from Somalia, as well as tribal and ethnic violence that continue to occur.

Corruption is the largest hindrance in Kenyan development, economics, governance, and overall infrastructure. The CIA Fact Book continually ranks Kenya within the top ten most corrupt countries in the world. The Kenyan Government fails to control this corruption, and is often the cause of the corruption occurring in the first place. This is one of the reasons that the unemployment rate in Kenya is so high at 40% and 50% of the population living below the poverty line, resulting in a weakness that may be manipulated by Al Shabaab and other terrorist organizations (CIA, 2011). All this makes the country even more of a strategic importance to the U.S. However, the average income per Kenyan is not very alarming at $1,600 per year, which is quite good for the area (CIA, 2011). Kenya's labor force consists of 17.9 million people, and is approximately 75% agriculture and 25% industry and services (CIA, 2011). In regards to agriculture, Kenya's Gross Domestic Product (GDP) is created largely from natural resources such as tea, coffee, wheat, sugarcane, fruit, dairy products, and meats. However, it is tourism that results in a large percentage of the annual income for Kenya, and with the increasing level of corruption and violence, tourism has begun to decrease as foreigners choose to not visit Kenya out of fear. If the corruption and amount of violence in Kenya is not controlled, the tourism will continue to decrease, and Kenyans may be more susceptible to recruiting efforts by terrorist organizations due to a need for money. Currently, the United Kingdom is Kenya's biggest export partner; however, this is not of vital concern. What is concerning is that 12% of all imports come from China, making the country highly reliable on a stable relationship with its counterpart. The U.S., on the other hand, only imports a 6% share of Kenya's total import needs, thus Kenya is much more reliant on China with regards to economic gain then they are to the U.S. (CIA, 2011). Currently, Kenya is in a budget deficit of 6.3% of its GDP (CIA, 2011).

Some developmental problems in Kenya have been the result of unfortunate circumstances such as the flooding that occurred between 1997-1998. Not only did the flooding destroy bridges, roads, and crops, but it also created epidemics of cholera and malaria (CIA, 2011). In a large part, the damage that Kenya received from the flooding was due to the poor construction of its bridges and roads, and standards in building requirements only seem to be on the decline with trade relationships with China. Agreements between the two countries are often made where China receives natural resources for very long periods of time. In exchange, China builds roads, bridges, etc. in Kenya. The problem that rises is that China will use inadequate time, labor, and materials and will build a second tier structure. Ultimately, the object constructed will start to degrade due to the low level construction used by China, but China will still be gaining from the long-term contract it has agreed on with Kenya. In the end, Kenya will have gained very little in exchange for large amounts of resources.

However, what is more of a hindrance to Kenya's development are the large amounts of tribal and ethnic violence coupled with a rise in terrorist activity. As stated earlier, Kenya has massive amounts of corruption and continually ranks in the top ten most corrupt countries in the world. In 1998 the U.S. Embassy in the nation's capital of Nairobi was bombed, killing 243 and injuring roughly one-thousand people. More recently, mass amounts of violence occurred following the elections of 2007. Raila Odinga, the opposition candidate representing the Orange Democratic Movement, was defeating incumbent Kibaki according to preliminary results by a wide margin of 57% to 39%. However, Kibaki still managed to win the election with 46% of the votes in comparison to the oppositions 44%. Foreign experts claimed that the election had been rigged. Odinga had promised to eliminate corruption and tribalism, a major issue in Kenya, during his run for election, but as a result of his defeat, violence between members of the Luo and Kikuyu tribes occurred in drastic amounts. Odinga himself was a Luo, whereas Kibaki was a Kikuyu. Within the first month of violence, 800 people had already been killed. By February over a thousand people had been killed, and the Kenyan Military could do very little. Finally, the United Nations intervened, and created a large multi-party cabinet consisting of 94 ministers, and both a president and prime minister. However, power sharing proved difficult between the two sides, and since the agreement, little has been accomplished by the government making Kenyans skeptical of the intentions and power of its government. The government is widely considered to have little to no power over its people, and tribalism remains a major issue in the country as a result. Even with international pressure, Kenya refused to launch an investigation into the results of the elections in 2007. The failure in these elections was vital since Kenya has only allowed multi-party elections since 1992. If the current amount of corruption and distrust towards the government continues, Kenya will remain a weak country, making it vulnerable to attacks and recruitment efforts from the neighboring Al Shabaab terrorist organization in Kenya.

Kenya is somewhat of an American stronghold in the U.S., and it is vital to American influence in the region. However, with the large amounts of corruption in the area, Kenya is becoming more of a target to terrorism from its neighbors, especially Somalia. Currently, Kenya is a safe haven for defectors, and is regarded as a fairly developed country in the region. With a high literacy rate, and large amounts of natural resources, Kenya has vast amounts of potential for outside investors. If the U.S. does not increase its interaction and aid with Kenya, this stronghold may potentially be lost to China or terrorist organizations. The amount of tribalism in Kenya is dangerous to the country's growth, and the violence resulting from corruption, tribalism, and terrorism has resulted in a large decrease in tourism, one of Kenya's main sources of income.

4.3 Systems Perspective of the Kenya Problem

Kenya is a complex system. Most modern countries behave in a stable manner as shown by the systemigram in Figure 4.1. Given the complex nature of the relationships between the variables of interest in Kenya the system models used produce outcomes that are not always intuitive. In order to better visualize and understand the Kenya problem, the use of complex system/SoS techniques will uncloak its relationships. Once these levels are broken down into simpler models, which are sub-levels to the overall system, the model is analyzed on the enterprise level. When breaking it down into more simple relationships, not only are risks being mitigated with potential hidden failures in the models, but also conceptually the relationships between the variables that represent Kenya's analysis are easier to understand.

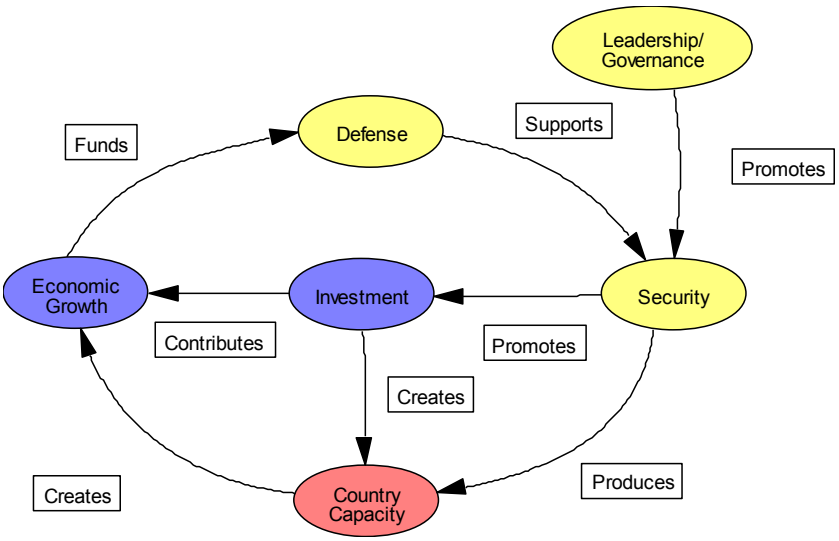


Figure 4.1 *Systemigram of how a defense, capacity, and investment all support economic growth*

Both CLD and SD models will be used to transition the problem from a complex system down to the enterprise level. Analyzing it on the enterprise level will allow for more visibility on the relationships between layers that create the output. A more visible model will be able to be more easily transitioned to fit and explain other regions around the world.

4.3.1 Building Partner Capacity

Like all emerging problems, competing definitions exist in the literature. For understanding this problem we propose the following relevant definitions:

- Nelson (2006) defines S&R as the process to achieve a locally led and sustainable peace in a dangerous environment. The military role in this process is halting residual violence and ensuring order and security, including those reconstruction efforts required to repair enough damage to enable restoration of the most essential services. Figure 4.2 is a CLD that shows the roll of displaced people and conflict.
- Building partner capacity can best be defined as "targeted efforts to improve the collective capabilities and performance of the DoD and its partners" (Department of Defense 2006). A major component of BPC is security force assistance (SFA). This is defined by the DoD as department activities that contribute to unified action by the U.S. government to support the development of the capacity and capability of foreign security forces and their supporting institutions (Department of Defense 2010). Building partner capacity is accomplished mainly through training and equipping the partner nation's military and improving their quality of life through infrastructure improvements, education, and equipping the civilian workforce. Our military is trained to fight and win the nation's wars. However, in modern conflicts to include S&R, non-military capacity building actions have become as important as any kinetic weapon system.
- Country capacity is the ability of a country and government to perform the functions of providing for the populace, solves problems, and achieves objectives in a sustainable manner. Figure 4.3 shows a systemigram of some of the essential elements of country capacity.

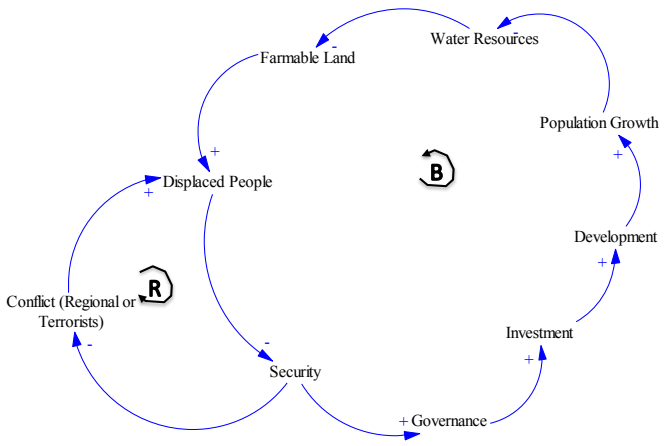


Figure 4.2 *CLD showing the roll of displaced people and conflict*

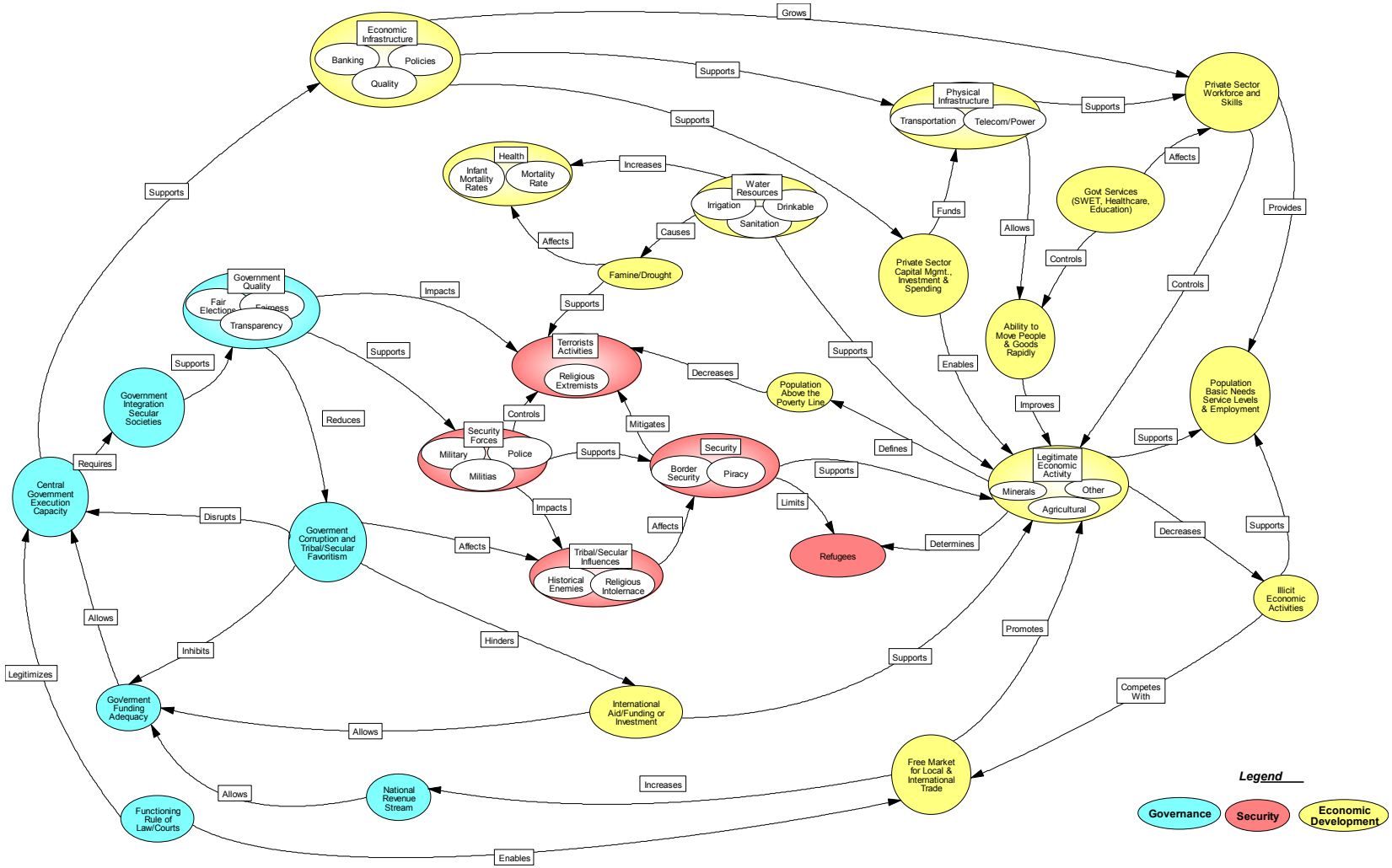


Figure 4.3 *Systemigram for Kenya*

4.3.2 General Kenya Model

Country capacity is the ability of a country and government to perform the functions of providing for the populace, solves problems, and achieves objectives in a sustainable manner. Figure 4.1 shows a systemigram of some of the essential elements of country capacity. As shown in that figure we group all elements into three categories: governance, security, and economic development. This systemigram was an important first step in developing our final SD model in that it provided some logical linkages between elements.

4.3.3 Water Security

As shown in Figure 4.4, our systemigram illustrating the relationships of water resources in Kenya there are many significant components that comprise this interrelated relationship. In regards to water resources, those components are comprised of health, water related disasters, terrorist activities, in addition to legitimate economic activity. Furthermore, it is imperative to note that the topic of water resources is so complex, that it requires the incorporation of components from a multitude of sectors of society.

At the heart of water resources is the trinity of sanitation, irrigation, and potable water. Without a balance, purity, and separation of all three; the overall quality of life of the Kenyan people suffers greatly. From the systemigram the reader can note that without adequate access to birth control and sexual education, rapid population growth drastically decreases the overall supply of water resources. On the opposite side, Kenya's water resources drastically affect the overall health of the population, specifically infant mortality rates and overall mortality rates. An important factor of health is also the abundance of waterborne disease within the country that devastates the overall health of the population.

Within the context of water related disasters, both desert encroachment and flooding comprise this terrible element of the systemigram. A major problem within Kenya is how unmanaged industrial growth both decreases water resources and ultimately contributes to water related disasters. Once those water related disasters occur, usually environmental events such as dust storms, flooding, and erosion ensue which drastically tear away at the bedrock of Kenya's agricultural production. Within the element of agricultural production, it is important to not how governmental agricultural policies drastically affect both agricultural production which ultimately affects food availability. Throughout Kenya's history, the lack of food has almost always resulted in food crises mainly because Kenya has a poor food distribution structure. Without a means of efficiently and effectively distributing food to Kenya's vast population across its diversely geographic terrain, food crises will almost always be attributed to a lack of adequate food distribution infrastructure.

When we initially conceived of this research was wanted to investigate the role of water and how it drove conflict. However, as shown in Figure 4.2 and 4.3, water is an important because of its role in development and displacing people. However, trying to address its affects in isolation was not feasible until we better developed the SD model. In summary, Figure 4.4 was useful in helping understand how water affected government legitimacy. However, the detail was to fine to use in our SD models. As we refine our SD model, calibrate, and ultimately conducted a meaningful study beyond this proof of principal demonstration this type of detailed interdependencies will need to be developed.

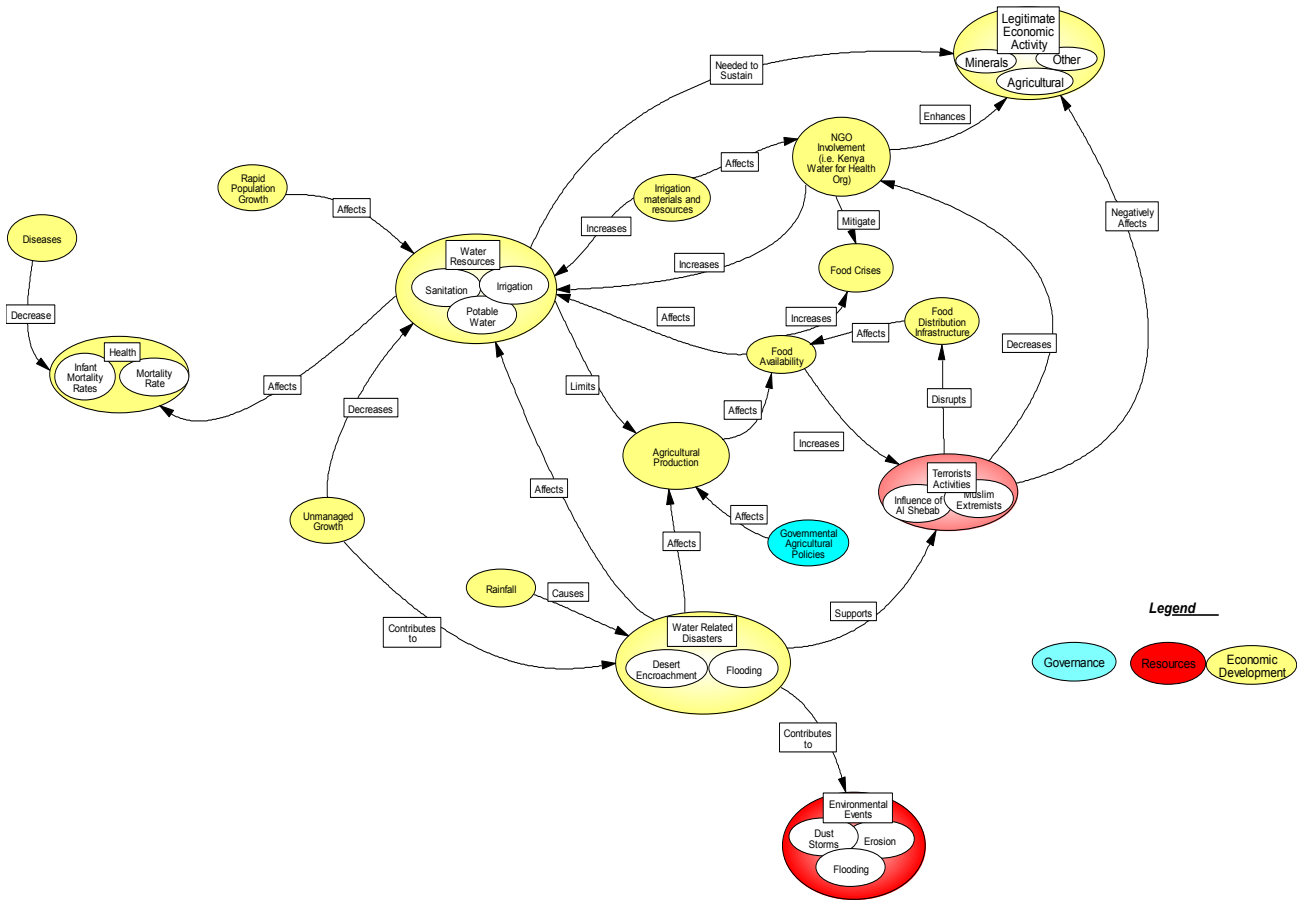


Figure 4.4 *Systemigram for water security in Africa*

From our research we have identified that terrorist activities within Kenya, specifically the influence of the Al Qaeda backed organization Al Shabaab amongst other Muslim extremists tend to gain a foothold of the country's food distribution infrastructure in order to use food as a weapon. This was a tactic of Al Shabaab during the conflict in that Somalia and is still leveraged today throughout the Horn of Africa. An increase in terrorist activities tends to have a drastic negative effect upon the legitimate economic activity of Kenya; specifically Kenya's minerals, agricultural, and tourism industries. Terrorist activities also curtail the efforts of NGO involvement such as the Kenya Water for Health Organization, which is dependent upon the irrigation materials and resources that sustain the sanitation, irrigation, and potable water of the country.

Ultimately, without a balance of the multitude of elements that influence Kenya's water resources, terrorist activities will continue to influence the country's economy, health care system, food network, and other factors of society. Furthermore, while difficult for Kenya's abundantly corrupt governmental system to gain strong control of the country's water resources, it is significantly necessary in order for the country to have any chance of long-term holistic development and security.

4.4 Causal Loops of Kenya Problem

4.4.1 Introduction

Causal loops are useful to the Kenya problem in both their adaptability and transformability from a qualitative state into a quantitative state. Causal loops provide a visual model displaying both relationships and affects between variables. Once the variables that influence the system are identified, interrelationships can be established.

In the case of Kenya, the key areas of focus in this problem are too complex to be immediately built into a single quantitative model that would provide a reliable output; instead, each key area must be broken down into the specific variables that influence it and the causal loop diagram does not have a limit to the number of variables or loop structures that can be displayed. Causal loops provide an outlet to show a breakdown in the relationships between variables that influence the key areas such as water, security, essential services, government legitimacy, economics, or country capacity without oversimplifying the output. As a secondary benefit for a quick basic understanding of the solution breakdown, the causal loop is a visual tool for easy communication purposes to be used in identifying the interdependences of variables in the system that directly result in a butterfly affect across the surrounding areas to Kenya.

Lastly, what the CLD provide is a stepping-stone for SD modeling process. The causal loop is transformable into a SD model, which uses the variables interdependencies identified in the causal loops along with rates of change in a system to achieve a working model with an quantitative output that can be analyzed to understand the overall behavior of the system. In terms of Kenya the CLD will be useful in piecing together a working SD model that will show the sensitivity in the key areas of focus and how they relate to one another as variables initial values are altered in the system.

4.4.2 Government Legitimacy

As shown in figure 4.5, at the center of the Government Legitimacy CLD, the variable Essential Services feeds into Country Capacity, and Government Legitimacy variable itself. The relationship between Essential Services and Country Capacity is a reinforcing relationship that means that as each variable increases, the other increases as well. The loop between Government Legitimacy, Essential Services, and Country Capacity also forms a reinforcing loop because as the government becomes more efficient and transparent more services can be provided and the overall capability of that country directly increases as a result. Additionally, there is a significant reinforcing loop comprised of GDP, Security, Government Legitimacy, Essential Services, and Country Capacity that indicates that all variables are directly correlated therefore as one increases, they all increase.

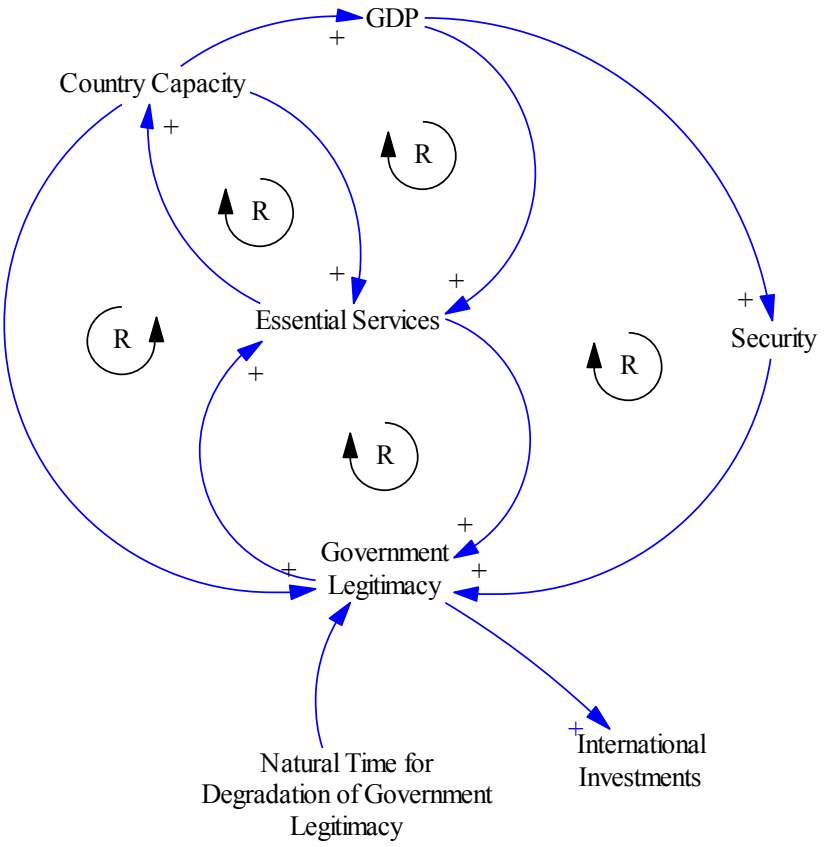


Figure 4.5 *Government Legitimacy CLD*

4.4.3 Security

The Security CLD shown in Figure 4.6 is complex in nature, comprised entirely of balancing loops. One of those balancing loops being the relationship between security's ability to decrease the Probability of killed in action (KIA) that increases host nation security forces killed in action (KIA) subsequently decreasing Probability of Enlistment. Included in this relationship is how the Probability of Enlistment increases the Military Age Population that also increases the Host Nation Security Forces that has a positive effect on Troop Level and the overall Effect of Troops. A significant second balancing loop identifies the relationship between Security's ability to decrease the Security Gap that increases Desired Troop Level. The Desired Troop Level subsequently increases the actual Troop Level (which is comprised of U.S. forces and African Union forces), which positively affects the overall Effect of Troops.

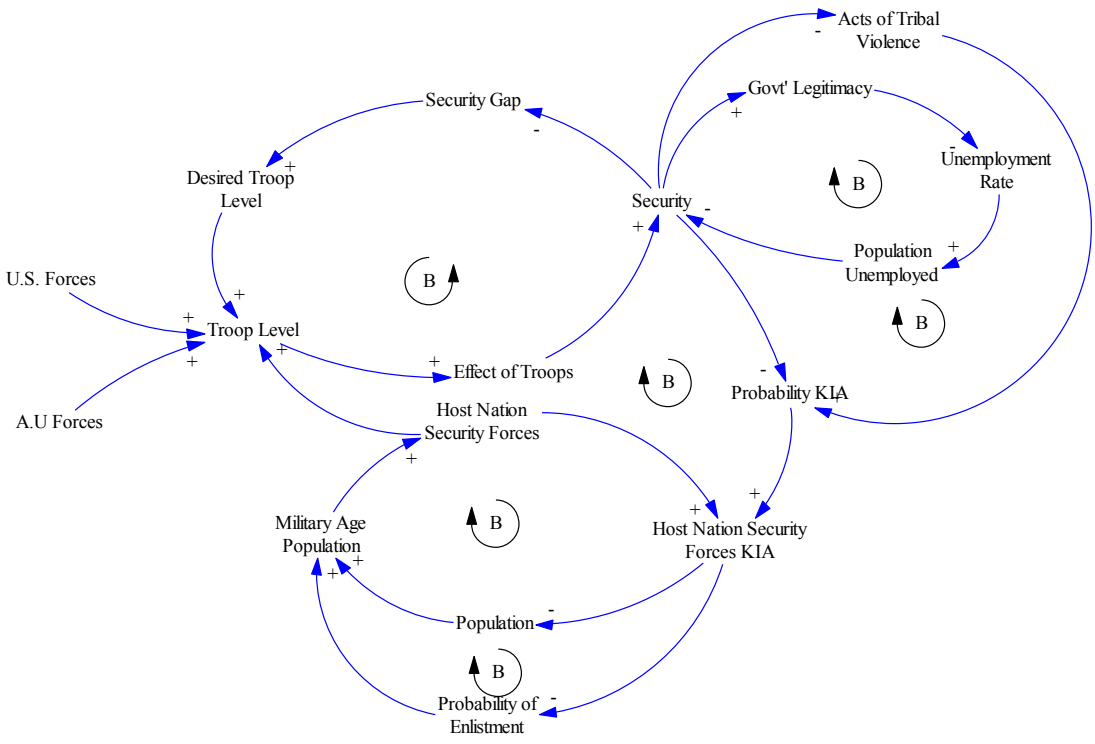


Figure 4.6 *Security CLD*

4.4.4 Economics

The Economics CLD shown in Figure 4.7 is also a complex causal loop as it contains predominantly balancing loops however also a reinforcing loop relationship. A significant balancing relationship is centered around GDP and its positive effect on Net Migration that has a positive effect on Labor Force. As the Labor Force drastically increases due to an influx of Net Migration, this event ends up having a negative effect upon GDP that ultimately comprises the balancing relationship between these three variables. The reinforcing loop is also significant because it demonstrates the positive relationship between GDP, Education Level, and Country Capacity that ultimately increases the nation's GDP.

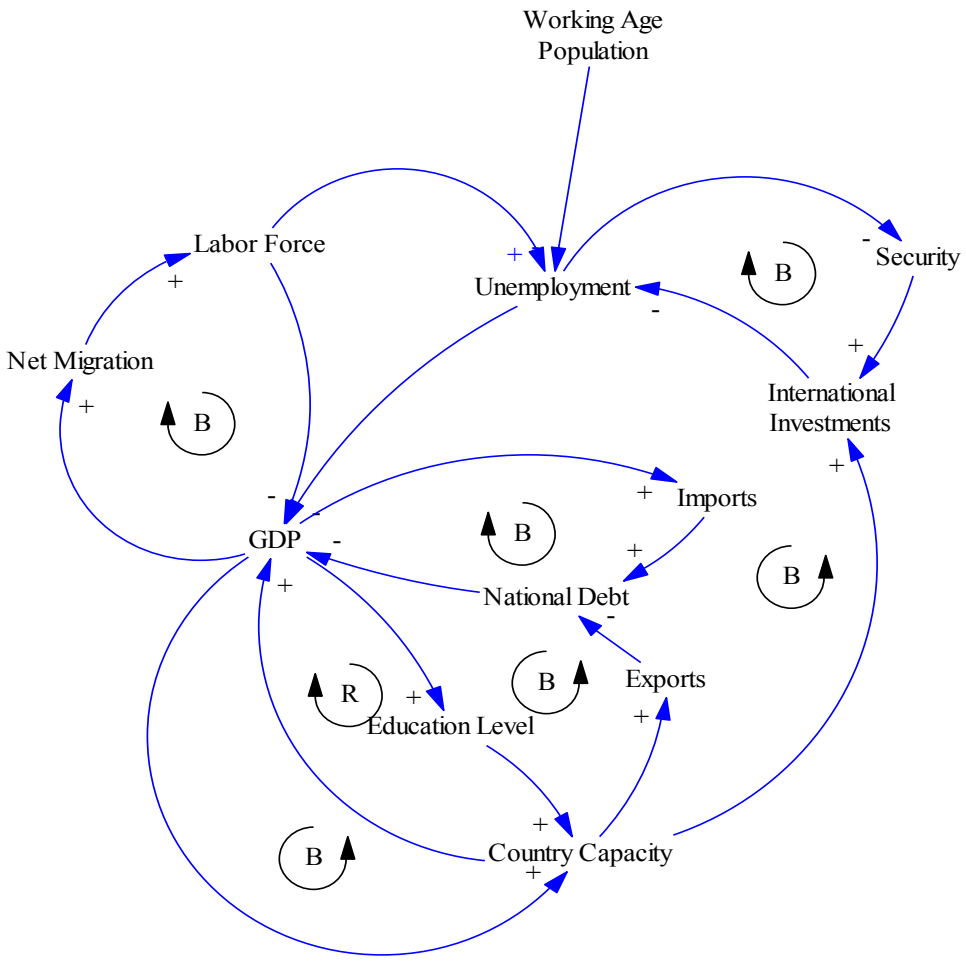


Figure 4.7 *Economics CLD*

4.4.5 Country Capacity

Country Capacity is the most complex CLD and as shown in Figure 4.8 is comprised of a multitude of variables that display both multiple balancing and reinforcing relationships. One of the significant balancing loops within this model is the relationship between Country Capacity positively affecting Access to Capital that has a negative effect on the country's Unemployment Rate. As the country's Unemployment Rate decreases the Population Unemployed increase which has an important positive correlation to the number of Acts of Tribal Violence that ultimately decreases the Security level of the country that has a lasting negative impact on the overall Country Capacity.

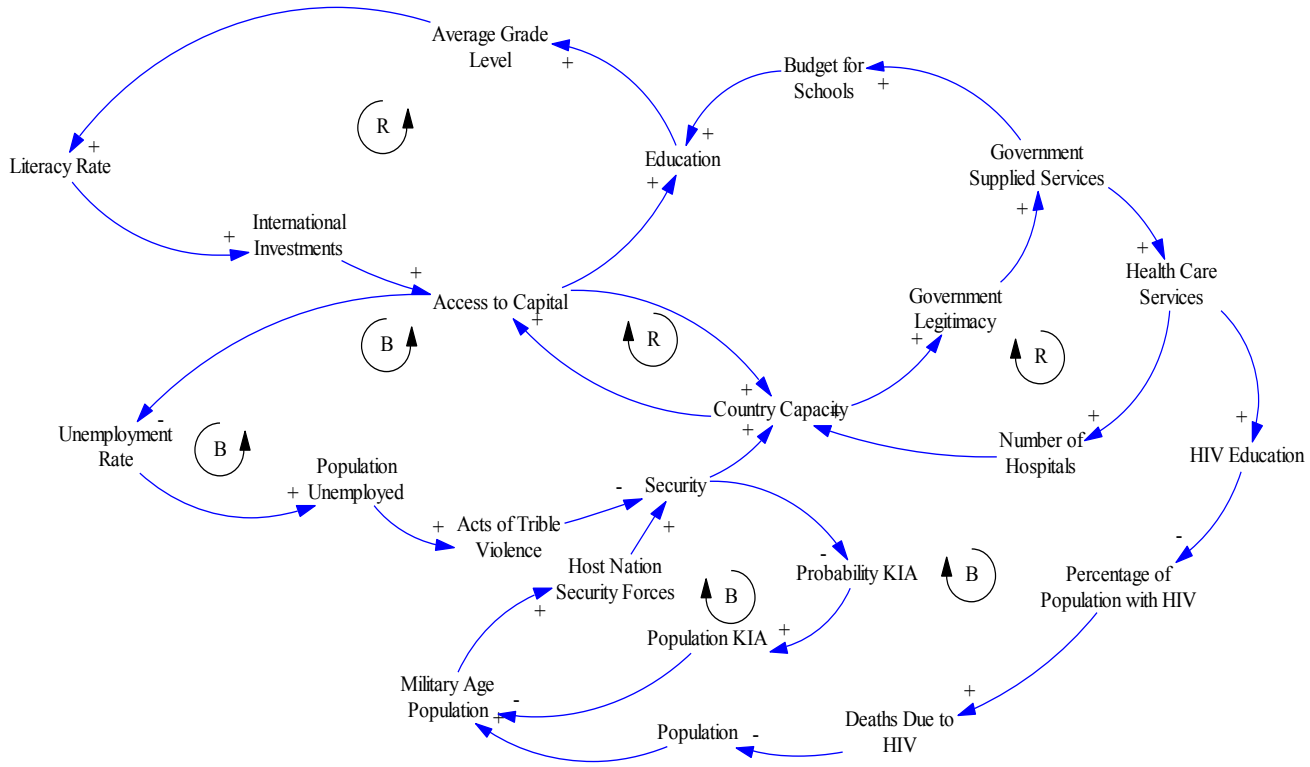


Figure 4.8 *Country Capacity CLD*

4.4.6 Essential Services

One of the key relationships within the Essential Services CLD shown in Figure 4.9 is the reinforcing relationship between GDP's positive effect on Essential Services that has a positive effect on the overall Road Services within the country. As the Road Service capability increases so does the overall Country Capacity that ends up increasing International Investments that ultimately increases the country's GDP. There is also an important reinforcing relationship with the focal point being Essential Services' ability to increase the Budget for Medical Services that increases the Number of Hospitals. As the Number of Hospitals increases the Average Lifespan also increases which ultimately has a positive effect on the country's Population.

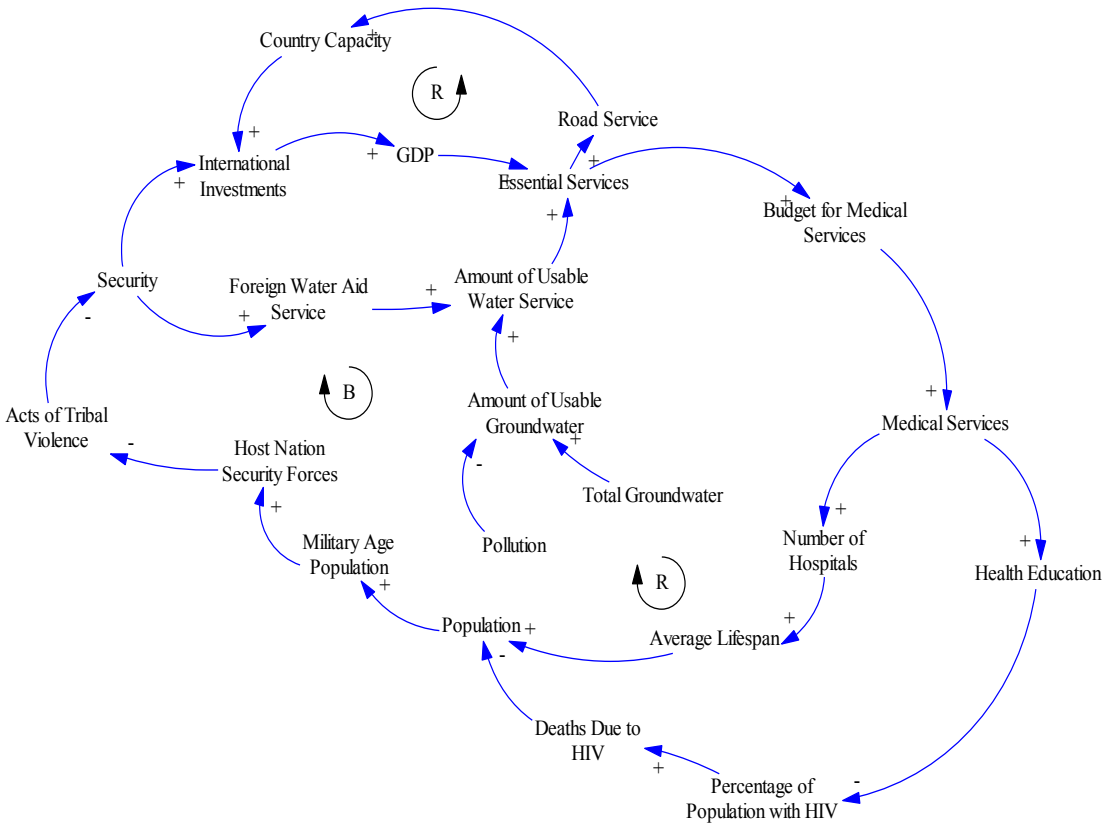


Figure 4.9 *Essential Services CLD*

4.5 Systems Dynamics Model

The next step in our solution methodology was to take the qualitative models, systemigrams and causal loops, and move in to a quantitative modeling technique. For the model we used Vensim®, a modeling tool used to associate values with variables. Each variable is associated with a value, unit, and definition. These all affect the stocks, which have an equation that integrates the variables into an outcome. The stocks are affected by flows, which either increase or decrease the stock, and are also associated with an equation, unit, and definition.

The SD model allows us to move from a qualitative model to a quantitative model that can produce results as behaviors and values. In the case of this model, it allows us to see the interdependencies between our five layers: Government Legitimacy, Security, Economics, Country Capacity, and Essential Services. We modeled each of these layers and determined a point of relation that connected them to the other layers to develop the overall model.

4.5.1 Government Legitimacy

The Government Legitimacy model measures the perceived legitimacy of the government by the host nation population in the country based on the four other layers; Essential Services, Country Capacity, Security, and Economics, and their effects as shown in Figure 4.10. This Government Legitimacy model is the main model, and ties in the other four layers. The Government Legitimacy model is created with two simple stocks and flows. The center of the model is the stock labeled Government Legitimacy. Going in to the stock is a rate that is the Increase in government legitimacy, and exiting the model is the rate at which there is a decrease in government legitimacy. These rates are affected by the other four layers. Each one of the variables associated with the layers are labeled with “Effect of” layer, and will either increase or decrease Government Legitimacy. For Increase in Government Legitimacy, the Government Legitimacy will increase based on an increase in the variable Effect of Essential Services on Government Legitimacy, Effect of Security on Government Legitimacy, GDP Effect on Government Legitimacy, Effect of Country Capacity on Government Legitimacy, as well as the Gap in Government Legitimacy, and the Time for Government Legitimacy to Increase. The “Effect of” variables are simply the weight associated with each one of the layers. The Gap in Government Legitimacy is the difference between the Desired Government Legitimacy and the current Government Legitimacy. Also, the Time for Government Legitimacy to Change is simply the natural time for a change in Government Legitimacy to take place. The Degradation of Government Legitimacy flow is the Government Legitimacy and the Time for Degradation of Government Legitimacy which is the natural time for Government Legitimacy to decrease.

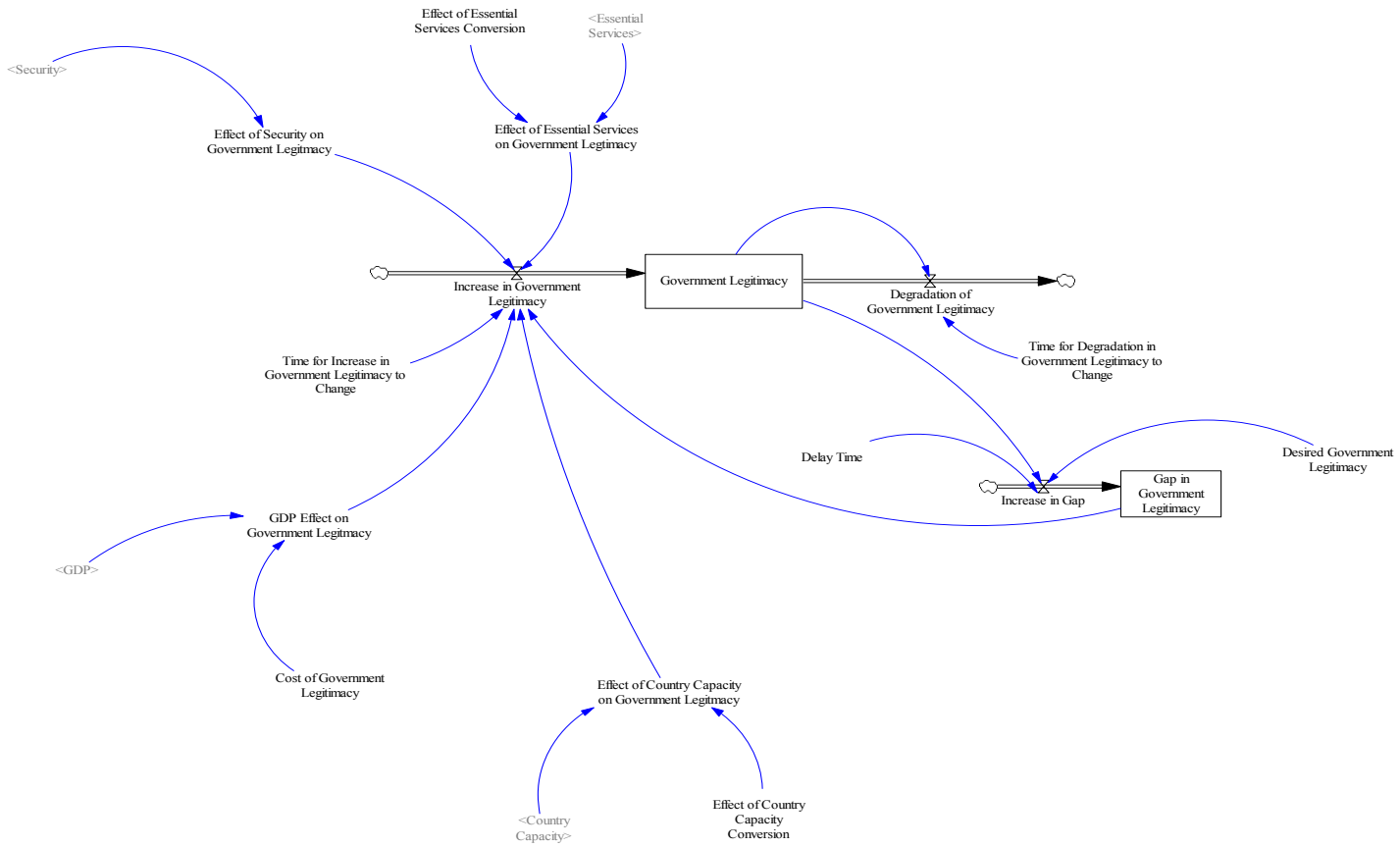


Figure 4.10 *System dynamics model for Government Legitimacy*

4.5.2 Security

The Security model explains the variables that effect the security both positively and negatively of the country being assessed. The model as shown in Figure 4.11 consists of three stocks; the first is what we are trying to measure, Security, the second is Host Nation Security Forces, and the third is Population. The Population as well as the % Military Age and Time to Age all affect the Military Age Population. The Enlistment Rate along with the KIA Rate and Retirement Rate will determine the number of Host Nation Security Forces. The KIA Rate will increase based on the number of attacks, and this will decrease the number of Host Nation Security Forces. The Retirement Rate will also lower the number of Host Nation Security Forces, and this is affected by both the initial Host Nation Security Forces and the Average Time in Service for a member in the military. From the Host Nation Security Forces stock, it goes to the external variable Troop Level. Troop Level is also affected by the number of African Union Forces and U.S. Forces as well as the Desired Troop Level. The Effect of Troops on Security as well as the Troop Level affect the Effect of Troops. The Effect of Troops as well as the natural Time to Implement Security causes an Increase in Security. The flow Security Degradation is changed based on Security and the Time to Degrade Security.

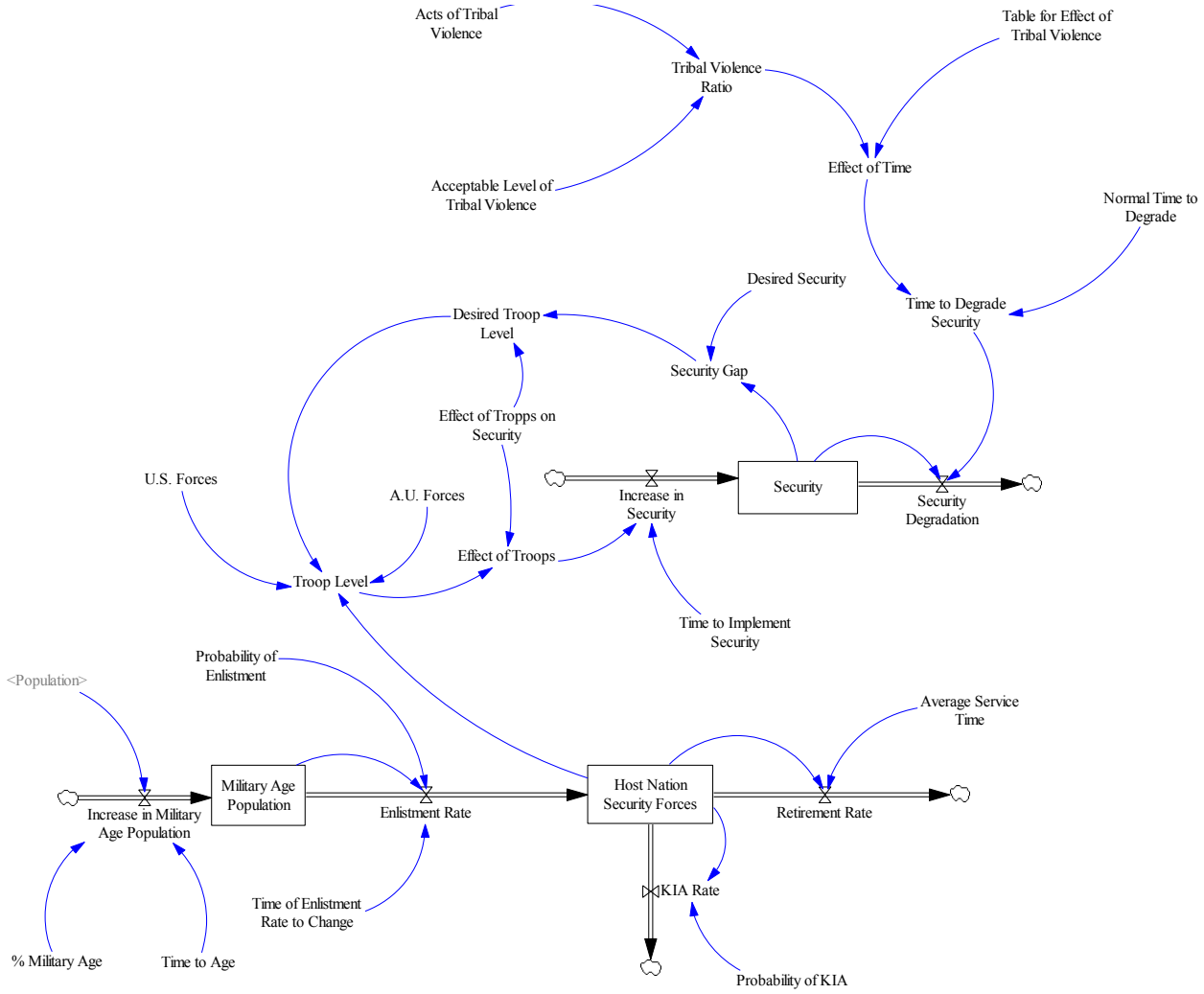


Figure 4.11 *System dynamics model for Security*

4.5.3 Economics

The Economics layer of the model as shown in Figure 4.12 is based around Gross Domestic Product (GDP). GDP is the center stock and has a flow Increase in GDP going in to the stock and Decrease in GDP going out of the stock. The Increase in GDP flow is affected by International Investments, Government Investment, Private Consumption of Goods, International Loans' Interest and Payments, Total Exports, and the natural Time to Change GDP. The variable International Loans' Interest and Payments is simply the amount of money that is being received from loans given to other countries from the host nation. The Decrease in GDP flow is affected by the current GDP, National Debt, Total Imports as % of GDP, as well as the Time to Change GDP. The second stock is Unemployment Rate and has a flow going in to it labeled Increase in Unemployment Rate and one going out named Decrease in unemployment Rate. The Unemployment Rate will Increase based off of the Ratio of Previous and Current Household Income and the Time for the Unemployment Rate to Change. The Decrease in Unemployment Rate is affected by International Investments, Average Wage (as a shadow variable), and Time for Unemployment Rate to Change. To determine the Population Unemployed we used Working Age Population and the Unemployment Rate stock.

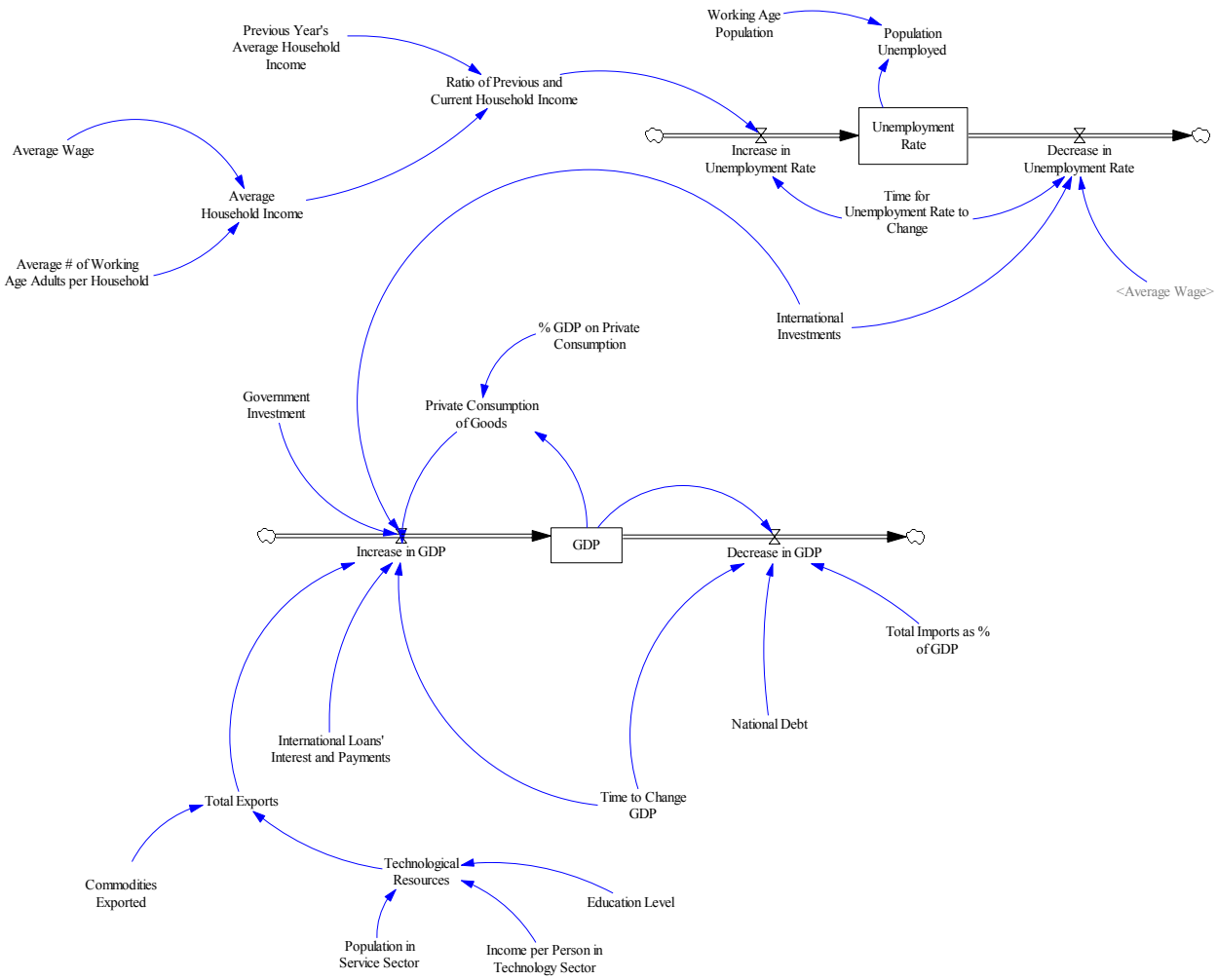


Figure 4.12 *System dynamics model for Economics*

4.5.4 Country Capacity

The Country Capacity is the potential growth of the country. The SD model for Country Capacity is shown in Figure 4.11. Basically, a smaller country will not have as much potential as a larger country that has more resources. The Country Capacity layer of the model is the most complex. It is centered around a stock labeled Country Capacity which has a flow going in to it, Increase in Country Capacity, and one going out, Decrease in Country Capacity. The Increase in Country Capacity flow is affected by Effect of Education on Increase in Country Capacity, Effect of Increase in Population, Effect of Access to Capital on Increase in Country Capacity, and Time to Increase Country Capacity. The Decrease in Country Capacity flow is caused by the Effect of Education on Decrease in Country Capacity, Effect of Increase in Population, Effect of Access to Capital on Decrease in Country Capacity, Effect of Decrease in Population, and Time to Degrade Country Capacity. All of these variables stem from five other stocks; Literacy Rate, Average Grade Level, Education, Population, and Access to Capital. Each of these stocks has a flow going in to them, which causes an increase in the stock, as well as a flow exiting the stock, which causes a decrease, with the exception of Population which has two outflows.

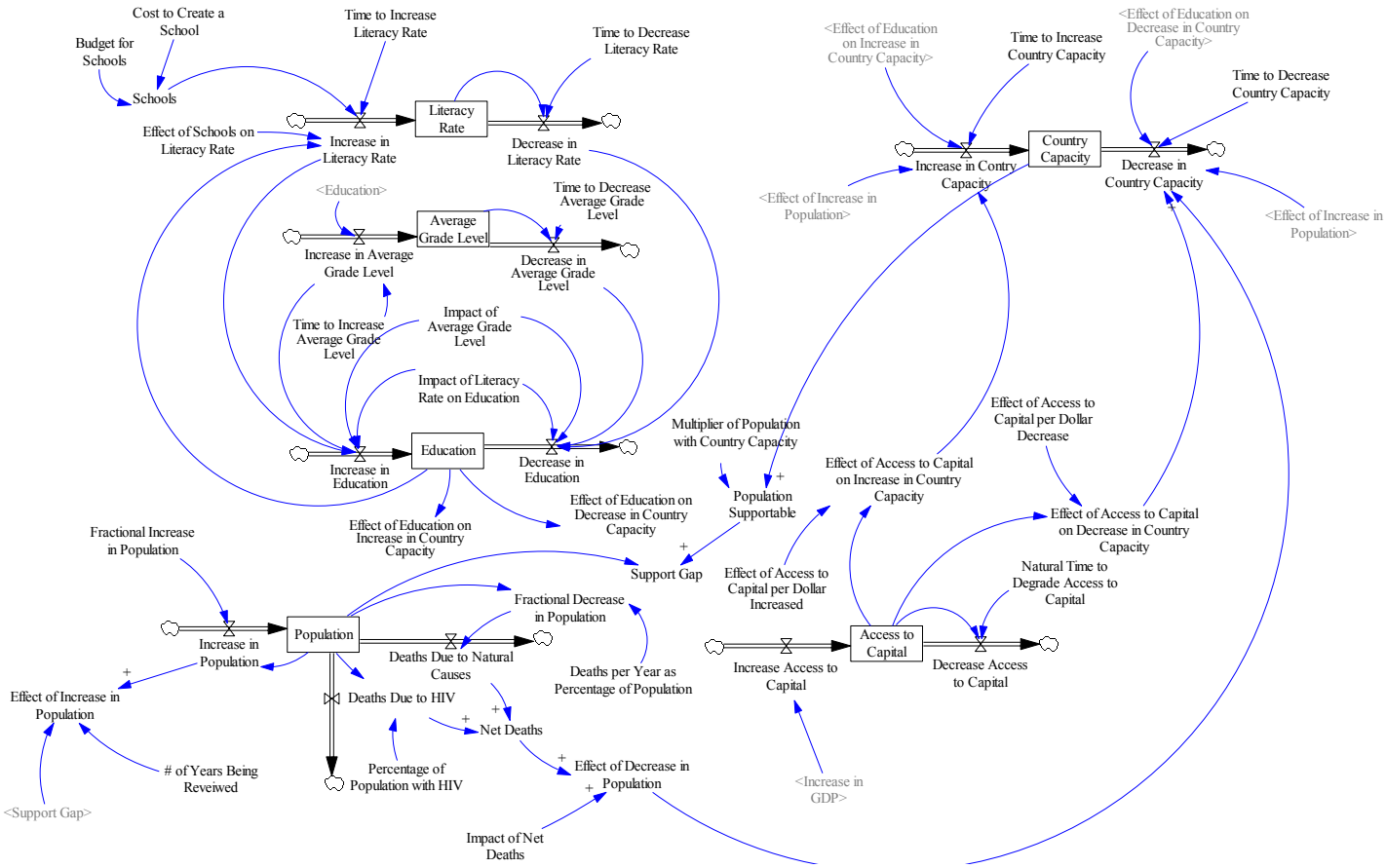


Figure 4.13 *System dynamics model for Country Capacity*

4.5.5 Essential Services

The Essential Services layer of this model describes the level of services needed by the population of a country, such as water, medical care, access to hospitals, etc. that are supplied by the country. The SD representation of essential services is shown in Figure 4.14. The model is based around the stock Essential Services and has a flow going in to the stock, Increase in Essential Services, and one leaving the stock, Degradation of Essential Services. There are four other stocks that affect Essential Services; Medical Services, Road Services, Usable Water Service, and Government Supplied Services. Each one of these also has a flow going in to and out of the stock. The Increase in Essential Services flow changes based on the flow Medical Services Development, Increase in Government Supplied Services, Increase in Usable Water, and Increase in Road Services. The Degradation of Essential Services flow changes based on Water Degradation, Medical Services Degradation, Road Service Decay, and Decrease in Government Supplied Services. There is no time associated with a change in Essential Services because there is time paired with each one of the stocks affecting Essential Services; therefore, time is indirectly related.

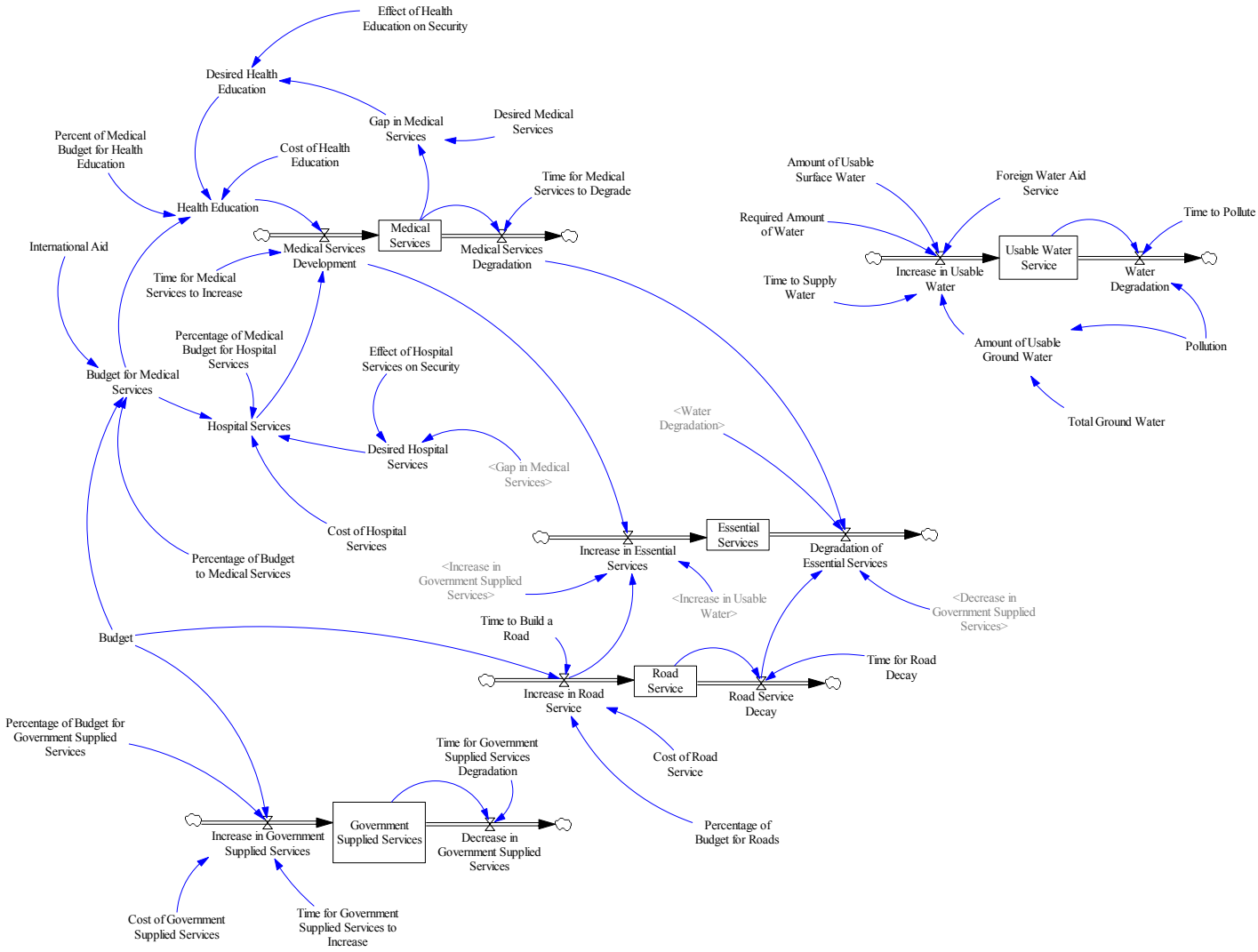


Figure 4.14 *System Dynamics Model for Essential Services*

4.6 Model Results

Figure 4.15 shows the spreadsheet we developed to organize our input data. Appendix A contains all of the input data used for our model. Figure 4.16 shows our qualitative capturing of the expected behavior of the layers of interest. The comparison shown in this figure shows what we expected and what the model actually produced. This comparison shows that more calibration and variable refinement is needed for the model to accomplish actual predictive measures but that the mathematical relationships exist and function properly.

	A	B	C
1	Variables of the Consolidated Model		
2	Economics	($=USD)	
3	Data	Figure	Source
4	Working age population	18390000	http://www.theodora.com/wfbcurrent/kenya/kenya_economy.html
5	Average wage / salary	$4,812	http://www.payscale.com/research/KE/Country=Kenya/Salary
6	International Investments	$3,012,400,000	CIA Factbook
7	Unemployment Rate	40.00%	CIA Factbook
8	Time for Unemployment Rate to Change	3 years	http://www.indexmundi.com/g/g.aspx?c=ke&v=74
9	Previous Year's Average Household Income	$8,160	CIA Factbook
10	Average # of Working Age Adults per Household	2.8101	CIA Factbook
11	Government Investment	$14,729,000,000	CIA Factbook
12	Private Consumption of Goods	$37,655,641,432.37	http://www.tradingeconomics.com/kenya/household-final-consumption-expenditure-ppp-us-dollar-wb-data.html
13	Commodities Exported	$5,443,000,000	CIA Factbook
14	Population in Service Sector	10,753,335	CIA Factbook
15	Income per Person in Technology sector	$15,367	http://www.payscale.com/research/KE/Country=Kenya/Salary
16	Education Level	11 years	a shadow variable**
17	International Loans' Interest and Payments	$321,400,000	https://www.cia.gov/library/publications/the-world-factbook/geos/ke.html
18	National Debt	$34,677,500,000	CIA Factbook
19	Total Imports as % of GDP	0.166	CIA Factbook
20	Time to Change GDP	3 months	Inferred from CIA Factbook
21	Current GDP (Purchasing Power Parity)	$71,500,000,000	https://www.cia.gov/library/publications/the-world-factbook/geos/ke.html

Figure 4.15 *Data sources for the economics layer of the system dynamics model*

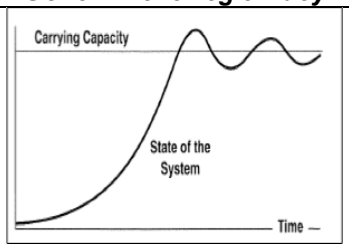
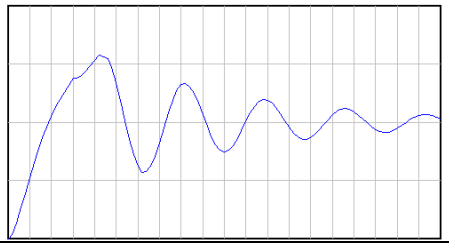
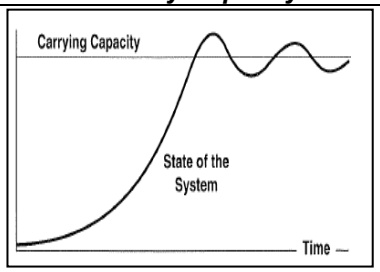
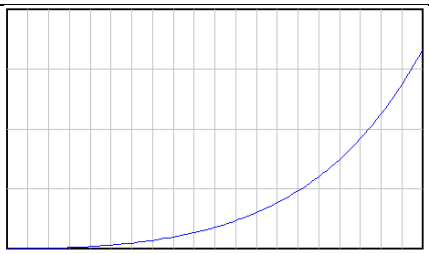
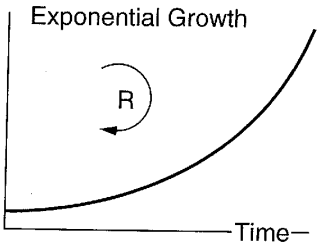
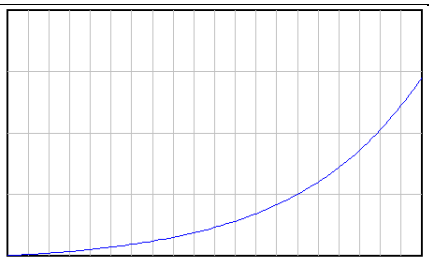
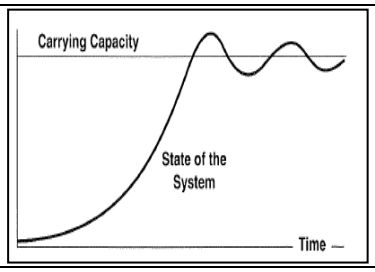
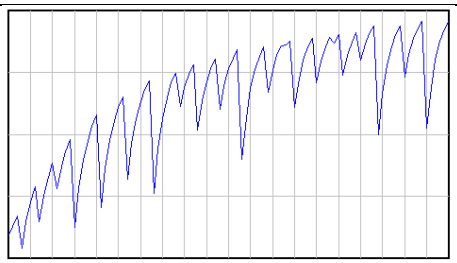
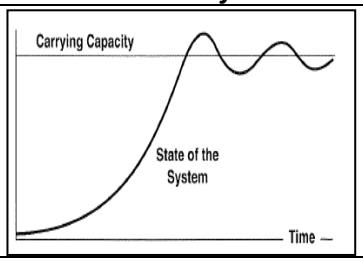
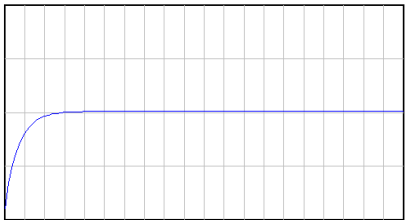
Expected	Model Produced
Government Legitimacy	
	
Country Capacity	
	
Economics	
	
Essential Services	
	
Security	
	

Figure 4.16 *Predicted and actual behavior of the 4 layers and the total systems behavior layer*

Chapter 5
Summary

5.1 Summary

The SD model we have created relates five different aspects of the behavior of Kenya as a complex system representation of a nation into a quantitative representation. Each "layer" - Government Legitimacy, Country Capacity, Essential Services, Economics, and Security - is modeled independently and then interdependencies between each layer are found and connected. This modeling technique allows the user to see more aspects of such a complex problem. It also allows the user to see how different layers affect one another. In our research and literature reviews, our group was not able to find a SD model that shows the interdependencies of multiple layers in as much detail. We believe that the integration of multiple layers into one solution model using system of systems diagramming and modeling techniques is a new and novel approach, with much promise, to help quantify investments in various regions.

The model we have created has shown the ability of SD to model across various layers. It has exemplified that complex problems can be modeled using system of systems modeling techniques. We believe that this model has the ability to eventually be adjusted to fit other countries, as well as used by other organizations such as NGOs if some of the variables are adjusted. We intended to prove such a methodology would work in modeling such complex problems, and we have done just that. Basically, our group has attempted to prove the utility of system of systems and complex systems tools in modeling such in-depth problems. Our goal was to demonstrate the utility of such a model using real life and meaningful data.

However, there were some challenges associated with such a modeling technique. First off, it was very difficult to determine where interdependencies were linked. By this we simply mean that it was difficult to discover where each layer impacted one another. We believe that through our research we were able to get a good understanding on where these relationships took place; however, we also believe that there are some areas that interdependencies were not found. Our second challenge was finding accurate data to input into the model. To do this we first exhausted sources such as CIA Factbook to get the hard numbers. If the value for a variable could not be found through this method, we then researched and read various reports, and where we found matching data, we used this value. We also looked at historical graphs and saw where changes in data occurred to get our time variables. The next challenge we had was validating the model. This was difficult because we had to discover a way that would prove our model is correct. We believe that the most accurate way to do this is through inputting historical data and seeing if the outcome matches the historical proven outcome or value.

Our group believes this model can be used in a variety of ways. First, and most importantly, it can be used to quantify investments, basically, determine the "biggest bang for our buck." For example, the investor will be able to simulate the overall effect on the country or a specific area from their investment; therefore, they will be able to input their investment in to the variable that has the most overall affect. Second, the model will be capable of providing insight into unforeseen consequences. In the past water wells have been dug in areas with water shortages; however, the wells cause tribal disputes and increased violence. A model measuring only the water layer would not be able to predict the tribal violence; however, we believe that by linking layers together, we will be able to provide some insight in to these type of unforeseen results. Third, this model can help with strategic planning. It allows the user to model scenarios without having to encounter them. Therefore, this model can be a useful tool in planning for investments before it actually occurs.

In conclusion, we believe that the model we have created helps the understanding of how complex systems work. The model gives us the ability to simulate across numerous layers, thus exposing the interdependencies between different aspects of a region. From our research, we have not been able to find anything with as much complexity that models across different layers; this process can advance the

methodology used in modeling complex systems. Our model proves the usefulness of modeling interdependencies between aspects of complex problems, and it is our belief that this will help in the advancement of system of systems modeling techniques.

5.2 Future Research

The way forward for our research consists of calibrating our model, attaining more exact results and variables, expanding the model within the layers, and finally applying the model to other countries. In regards to calibrating the model we would focus on three tiers of structure, equations, and input variables which would work towards ensuring that each specific layer generates expected fundamental modes of dynamic behavior; with carrying capacity on the "y-axis" and time on the "x-axis." Currently, our Government Legitimacy and Country Capacity layers indicate purely exponential behavior with our desired state being exponential behavior with oscillation over time. Additionally, the Essential Services layer of the model has a purely oscillating behavior which is not ideal since the desired state for the layer is to have an exponential growth behavior with minimal oscillation after a period of time.

The way forward for our research also consists of expanding the models within the layers. This expansion would add complexity to the layer so that each output would be a more representative and accurate representation of the outcome. Lastly, further research would apply our model to other countries in order to analyze multi layer security, governmental, economic, and development related issues.

5.3 Acknowledgments

This work was funded by the Construction Engineering Research Laboratory (CERL) as part of the Engineering Research and Development Center under the Cultural Reasoning and Ethnographic Analysis for the Tactical Environment (CREATE) program. Mr. Tim Perkins was the point of contact at CERL. This CREATE program is focused on civil-military operations that are conducted with the invitation of a host nation with which the U.S. government already has friendly relations. In this context, the goal of civil-military operations is to enhance the legitimacy of the host nation government by improving its capacity to meet population needs and thus denying extremist and/or transnational criminal organizations room to maneuver among the population.

Chapter 6
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Appendix A
Data Sources and Annotated Bibliography

A.1 Annotated Bibliography
A.1.1 Africa

Assessment

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The Pilgrims Global Stability Index is the latest in a range of recently released Pilgrims Information Services products. It provides users with the ability to monitor terrorism, crime, economic and political stability across the world at the touch of a button. Each index is categorized using four, clearly defined, security levels. Unlike traditional risk maps, the Pilgrims Global Stability Index is continually updated, and users are alerted to new updates via email alerts, meaning that the user can be certain that the information they have is totally up to date.[2]

United States AFRICOM, "Indicator Reference List," August, 2011 (SECRET)

This draft-classified report contains hundreds of proposed assessment indicators. This report only lists these indicators and does not address sources for obtaining the data. The list is all encompassing and would be impossible to collect all of the identified assessment indicators.

Viewswire, "Political Instability Index," The Economist Intelligence Unit Limited. 19 March 2011. http://viewswire.eiu.com/index.asp?layout=VWArticleVW3&article_id=874361472

The political instability index (PII) draws on recent insights of the political science literature that seeks to identify and quantify the main social, economic and political factors and traits that are causally associated with, or that can predict, political instability. In particular, it draws on the work of the so-called Political Instability Task Force (PITF) based at George Mason University in the US. The PITF has created a simple model that has a rate of success of over 80% in identifying, ex post, outbreaks of serious instability for a data set that stretches back to 1955.

Conflict Drivers

Addison, T. "Post-Conflict Recovery: Does the Global Economy Work for Peace?" Helsinki: United Nations University/World Institute for Development Economics Research, Discussion Paper No. 2005/05, accessed at http://www.wider.unu.edu/publications/working-papers/discussion-papers/2005/en_GB/dp2005-05/_files/78091750837978401/default/dp2005-05.pdf

Countries as diverse as Afghanistan, Angola, and Sierra Leone are now attempting to recover from major wars, often amidst continuing insecurity. The challenge is to achieve a broad-based recovery that benefits the majority of people. The economic and social recovery of conflict-affected countries cannot be separated from their interaction with the rest of the world through flows of finance, goods, and people. Unfortunately, the global economy is not working well for peace. Trade reform, in particular, must take account of the need to create better, and non-violent, livelihoods for the world's poor: rich-country protectionism in agriculture hinders broad-based recovery and thereby harms the new international security agenda. This paper argues that post-conflict economies also need more external finance to support early institutional development and reform, thereby increasing the effectiveness of longer-term aid inflows.

Clements, Kevin "Towards Conflict Transformation and a Just Peace," Berghof Research Center for Constructive Conflict Management, edited version Aug 2004 (First launch Apr 2001), accessed at https://www.civcap.info/fileadmin/user_upload/Finland/finland1/berghof.PDF

[1] * Denotes that this reference was also directly cited in the report.
[2] Most of the annotations were taken directly from the reference website.

This chapter attempts to do two things: first, to make sense of some of the economic, political and social origins and dynamics of organized violence; second, determine how conflict analysis and conflict resolution processes might enable diverse actors concerned with violent conflict at the official and unofficial levels to change the attitudes, behaviors and institutions which generate structural (indirect) and direct violence. It will begin with an acknowledgement of the centrality of structural transformation for stable peace and an analysis of some of the underlying political and economic dynamics that form the backdrop to modern conflict. It will then examine how and why conflict resolution practitioners should focus more attention on the political economy of conflict in the analysis, design and implementation of conflict intervention processes.

Collier P, Hoeffler A. "Greed and grievance in civil war." Oxford Economic Papers 2004;56: 563-95.

This paper presents research to investigate the causes of civil war, using a new data set of wars during 1960–99. Rebellion may be explained by atypically severe grievances, such as high inequality, a lack of political rights, or ethnic and religious divisions in society. Alternatively, it might be explained by atypical opportunities for building a rebel organization. While it is difficult to find proxies for grievances and opportunities, we find that political and social variables that are most obviously related to grievances have little explanatory power. By contrast, economic variables, which could proxy some grievances but are perhaps more obviously related to the viability of rebellion, provide considerably more explanatory power. This article can be purchased at http://oep.oxfordjournals.org/content/56/4/563.full.pdf+html

Dutta, Indranil and Mishra, Ajit, "Does Inequality Lead to Conflict?" Research Paper No. 2005/34, United Nations University, World Institute for Development Economics Research, 2005, accessed at www.wider.unu.edu/publications/working.../rp2005-34.pdf

This paper presents a simple model to show how distributional concerns can engender social conflict. We have a two period model, where the cost of conflict is endogenous in the sense that parties involved have full control over how much conflict they can create. We find that anticipated future inequality plays a crucial role in determining the level of conflict in the current period. The model also provides an explanation for why similar levels of inequality may exhibit drastically different levels of conflict. Further, we argue that the link between inequality and conflict may be non-monotonic.

Goodhand J. "Enduring Disorder and persistent poverty: a review of the linkages between war and chronic poverty." World Development, Volume 31, Issue 3, March 2003, Pages 629–646

This paper examines the relationship between chronic poverty and violent conflict. Three types of potential linkage are examined: (a) long-term conflict causes chronic poverty, (b) chronic poverty causes violent conflict (grievance-based analysis), (c) resource wealth (rather than chronic poverty) causes violent conflict (greed-based analysis). Research to date has analyzed poverty-war linkages but chronic poverty has not been a focus. It is hypothesized that long-term conflict is likely to be a "driver" and "maintainer" of chronic poverty but a relationship in the opposite direction is less likely i.e., the chronically poor are less likely to ferment violent conflict than the transiently poor. The paper highlights the fact that current knowledge on poverty–conflict links is contested and further research is required on chronic poverty and war. This paper can be procured at http://www.sciencedirect.com/science/article/pii/S0305750X03000093

Governance and Social Development Resource Center, "Conflict," www.gsdrc.org, accessed June 1, 2012

This website contains a wealth of information papers on conflict drivers. Under the contact link a five chapter guide dealing with conflict to include understanding conflict, living in conflict, preventing and managing violent conflict, recovering from violent conflict, and intervening in conflict affected areas. Two supplements to the material are also contained on the website and deal with peace building and state-society relations.

Kok, Alida, Lotze, Walter, and Van Jaarsveld, Salome Van, "Natural Resources, the Environment, and Conflict," African Centre for the Constructive Resolution of Disputes (ACCORD), 2009, accessed at http://www.accord.org.za/downloads/reports/Natural_Resources_Conflict.pdf

The natural environment has often played a key role in conflicts throughout the world. Africa is no different. The 19th century scramble for the continent saw immense bloodshed as European countries battled over Africa's natural wealth. Decolonization in the 20th century seemed to embody a promise of freedom for Africa – politically, socially and economically. More than half a century later, this vision has not yet been realized and conflict is a constant feature. In many of the protracted conflicts in Africa, the control of natural resources and land is a major underlying issue. The Congo war, one of the biggest in the history of Africa, saw numerous actors involved in the exploitation of the country's vast and rich resources. To this day violence in North Kivu, in the eastern Democratic Republic of

Congo (DRC), is largely fueled by the drive to control these resources. Disputes relating to land, environmental and, more recently, climate change issues further add to Africa's woes. In Burundi, for instance, peacebuilding efforts are being hampered by land disputes, often exacerbated by environmental degradation. This report summarizes how natural resources have driven conflict throughout Africa.

Le Billon, Philippe, "The political ecology of war: natural resources and armed conflicts," Political Geography 20 (2001) 561–584, accessed at http://www.geog.ubc.ca/~lebillon/ecowar.pdf

Throughout the 1990s, many armed groups have relied on revenues from natural resources such as oil, timber, or gems to substitute for dwindling Cold War sponsorship. Resources not only financed, but in some cases motivated conflicts, and shaped strategies of power based on the commercialization of armed conflict and the territorialisation of sovereignty around valuable resource areas and trading networks. As such, armed conflict in the post-Cold War period is increasingly characterized by a specific political ecology closely linked to the geography and political economy of natural resources. This paper examines theories of relationships between resources and armed conflicts and the historical processes in which they are embedded. It stresses the vulnerability resulting from resource dependence, rather than conventional notions of scarcity or abundance, the risks of violence linked to the conflictuality of natural resource political economies, and the opportunities for armed insurgents resulting from the lootability of resources. Violence is expressed in the subjugation of the rights of people to determine the use of their environment and the brutal patterns of resource extraction and predation. Beyond demonstrating the economic agendas of belligerents, an analysis of the linkages between natural resources and armed conflicts suggests that the criminal character of their inclusion in international primary commodity markets responds to an exclusionary form of globalization; with major implications for the promotion of peace.

Stewart F. "Horizontal Inequalities: A Neglected Dimension of Development" Working Paper, CRISE, Department of International Development, University of Oxford, United Kingdom, 2003 accessed at http://economics.ouls.ox.ac.uk/13004/

Current thinking about development places individuals firmly at the center of concern for analysis and policy. This paper explores why groups are important for individual welfare and social stability, and argues that horizontal inequalities (i.e. inequalities between culturally formed groups) is a very important but neglected dimension of development. Most attention is focused on inequality between individuals. The paper recognizes that groups are socially constructed and malleable, often with fluid membership. Nonetheless, group's relative performance in economic, social and political dimensions is an important source of individual welfare and can cause serious political instability. This is illustrated by nine case studies, in which horizontal inequalities have led to a range of political disturbances, in some cases modified by state action to correct the inequalities. The paper concludes by pointing to an array of actions that can be taken to correct horizontal inequalities, arguing that such policies should form an important part of development strategy, but currently do not in either economic or political conditionality.

World Bank, "Conflict in Somalia: Drivers and Dynamics," January 2005 (draft) accessed at http://siteresources.worldbank.org/INTSOMALIA/Resources/conflictinsomalia.pdf

To help guide policy and program development in Somalia when the World Bank began reengaging after more than a decade, the Bank's Country Director decided to conduct a conflict analysis of the country. The purpose of the exercise was to increase the Bank's and partners' understanding of conflict sources and dynamics, and contribute to conflict sensitivity in programs and interventions. The study was conducted in cooperation with Somali and international partners.

Governance

Bratton, M. "The politics of government-NGO relations in Africa," World Development, Vol 17, Issue 4, April 1989, pp 569-587

This article describes the growth of NGOs in Africa and proposes a framework for analyzing the dynamics of government-NGO relations. By means of examples drawn from Kenya and Zimbabwe, among other African countries, the article illustrates the strategies used by governments to exercise control, and by NGOs to assert autonomy. An argument is made that politics, rather than economics, best explain the contribution of NGOs to development, as well as the attitude of governments toward the burgeoning voluntary sector. This article can be purchased at http://www.sciencedirect.com/science/article/pii/0305750X89902635

Easterly, W. and R. Levine. "Africa's Growth Tragedy: Policies and Ethnic Divisions," The Quarterly Journal of Economics, Vol 112, No 4, November 1997, pp 1203-1250. http://williameasterly.files.wordpress.com/2010/08/17_easterly_levine_africasgrowthtragedy_prp.pdf

This paper examines the cross-country differences in growth rates requires to not only understand the link between growth and public policies, but also to understand why countries choose different public policies. This paper shows that ethnic diversity helps explain cross- country differences in public policies, political stability, and other economic indicators. In the case of Sub-Saharan Africa, economic growth is associated with low schooling, political instability, underdeveloped financial systems, distorted foreign exchange markets, high government deficits, and insufficient infrastructure. Africa's high ethnic fragmentation explains a significant part of most of these characteristics.

Jackson, R. H. and C. G. Rosberg. "Popular Legitimacy in African Multi-Ethnic States," The Journal of Modern African Studies, Vol 22, Issue 2, 1984, pp 177-198

This paper focused on the sociological aspects of political legitimacy in Africa. The paper is unique in that it addresses international and internal legitimacy. This paper can be procured at http://www.jstor.org/discover/10.2307/160548?uid=3739832&uid=2129&uid=2&uid=70&uid=4&uid=3739256&sid=47699052437087

Security

Jayne, T. S, A. Chapoto, I. J. Minde, and C. Donovan. "The 2008/09 Food Price and Food Security Situation in Eastern and Southern Africa: Implications for Immediate and Longer Run Responses," IDEAS. http://ideas.repec.org/p/ags/midiwp/54556.html

This study has three objectives: 1) to examine the impact of recent world food price changes on domestic maize and fertilizer prices in the region; 2) to assess possible changes in cropping patterns, national food production, and consumers' access to food in light of these price movements; and 3) to consider the implications for policy and program response by governments, donors, and the private sector. Against this backdrop, there is an urgent need for information about how the current food situation is unfolding in the region, the immediate policy response options, and the longer-term challenges and opportunities.

Haile, M. "Weather patterns, food security, and humanitarian response in sub-Saharan Africa," Philosophical Transactions of the Royal Society, Vol 360, No 1463, November 2005 pp 2169-2182. http://www.ncbi.nlm.nih.gov/pmc/articles/PMC1569582/

The purpose of this paper is to investigate how current advances in the understanding of climate variability, weather patterns and food security could contribute to improved humanitarian decision-making. The paper will propose new approaches for triggering humanitarian responses to weather-induced food crises. Timely and appropriate humanitarian aid will provide households with opportunities to engage in productive and sustainable livelihood strategies. Investments in poverty reduction efforts would have better impact if complemented with timely and predictable response mechanisms that would ensure the protection of livelihoods during crisis periods whether weather or conflict-related. With an improved understanding of climate variability including El Niño, the implications of weather patterns for the food security and vulnerability of rural communities have become more predictable and can be monitored effectively.

Miscellaneous

Anderson, David. *Histories of the Hanged: The Dirty War in Kenya and the End of Empire*. New York: W.W. Norton & Company Inc, 2005

This expose of the English colonial history of Kenya does a good job setting the record straight on some key issues, and brings to light the suppressed shadow side of the end game during the period of the Mau Mau. The infamous reputation of the Mau Mau always deflected attention from the totally inept and repressive nature of the last hurrah of the colonialists in the sunset of the British Empire. The colonialization of Kenya was ill conceived and predatory from the start, and the whole history was a riddled with a set of contradictions, such as the artificial creation of the exploitative white settler culture dooming Kenyan development from the first. You cannot let loose such a gang of people such as the white settler crowd, poor white trash in a true sense, without the rapid appearance of a malignant culture and infrastructure. This account brings to light what was quickly downplayed, the massive repression of the Kikuyu during the Emergency, with the creation of actual Gulags. The depiction of many of the judicial processes of

the period, including the trial of Jomo Kenyatta, is of a mockery of justice. The Kenyan style colony was really an instance of the Empire in decline from its nineteenth century peak and at least the British had the sense after Suez not to prolong the inevitable.[3] This book can be procured through Amazon.

Carmody, P. R. "Transforming Globalization and Security: Africa and America Post 9/11," Africa Today, Vol 52, No 1, Fall 2005 (97-120)

Africa has traditionally had a marginal and decreasing role in international affairs. Since the attacks of 11 September 2001, however, the continent has taken center stage in the emerging security discourse, and access to African oil is now a strategic priority for the United States, which now trades more with Africa than Central Europe and the former Soviet Union combined. This fact, and the potential threat from global terrorism, are reflected in emerging security regimes on the continent, bolstered by increased U.S. military assistance. Thus, global forces have penetrated not only African economic policymaking, but also security; however, increased military assistance and the suppression of human rights are further distancing society from the African state, worsening long-term instability and jeopardizing U.S. access to African oil. The creation of genuine security in Africa and the United States will depend on the reconceptualization of security as human security, and the addition of a substantive social-welfare dimension to globalization. This article can be procured at
http://muse.jhu.edu/login?auth=0&type=summary&url=/journals/africa_today/v052/52.1carmody.html

Central Intelligence Agency. *The World Factbook: Kenya*, accessed 5 September 2011, https://www.cia.gov/library/publications/the-world-factbook/docs/guidetowfbook.html

The CIA World Factbook is probably the most comprehensive open source site for obtaining information on the history, people, government, economy, geography, communications, transportation, military, and transnational issues for 267 world entities. In addition to economic, social, cultural data, the fact book contains maps of the major world regions, as well as Flags of the World, a Physical Map of the World, a Political Map of the World, and a Standard Time Zones of the World map.

Combined Joint Task Force: Horn of Africa, and Michael T. Franken, Rear Admiral. "About CJTF-HOA." CJTF & US AFRICOM. Accessed November 2011. http://www.hoa.africom.mil/index.asp#

Combined Joint Task Force – Horn of Africa conducts operations in the Combined Joint Operations Area to enhance partner nation capacity, promote regional stability, dissuade conflict, and protect US and coalition interests. Beyond organizational information the HOA website provides little information about the role of HOA, products, programs, etc.

Dagne, Ted, "Kenya: Current Conditions and the Challenges Ahead," Congressional Research Service, Library of Congress, Washington, DC, May 14, 2009, accessed at http://www.dtic.mil/dtic/tr/fulltext/u2/a501321.pdf

This report reviews the recent history of Kenya with the main focus on the post May 2007 elections. The report also addressed the key challenges in US-Kenya relations.

Department of Defense. *Country Handbook: Kenya*. Washington D.C.: Department of Defense, 2000.

The DoD Kenya Country Handbook, A Field Ready Reference Publication, DOD-2630-KE-010-00, is an FOUO publication that is similar in nature to the CIA Factbook. The reference can be bought at Amazon.

Easterly, W. and R. Levine. "Africa's Growth Tragedy: Policies and Ethnic Divisions," The Quarterly Journal of Economics, Vol 112, No 4, November 1997 (1203-1250), accessed at http://williameasterly.files.wordpress.com/2010/08/17_easterly_levine_africasgrowthtragedy_prp.pdf

This paper attempts to explain the cross-country differences in growth rates by linking growth and public policies. The research also explains why countries choose different public policies. This paper shows that ethnic diversity helps explain cross- country differences in public policies, political stability, and other economic indicators. In the case of Sub-Saharan Africa, economic growth is associated with low schooling, political instability, underdeveloped financial systems, distorted foreign exchange markets, high government deficits, and insufficient infrastructure.

[3] Taken from a book review by John C. Landon at
http://www.amazon.com/review/R2LRLA5678DGRT/ref=cm_cr_pr_viewpnt#R2LRLA5678DGRT

Africa's high ethnic fragmentation explains a significant part of most of these characteristics.

Klare, M. and D. Volman, "America, China, and the Scramble for Africa's Oil," Review of African Political Economy, Vol 33, No 108, Jun 2006 (297-309)

After decades of Cold War, when Africa was simply viewed as a convenient pawn on the global chessboard, and a further decade of benign neglect in the 1990s, the African continent has now become a vital arena of strategic and geopolitical competition for not only the United States, but also for China, India, and other new emerging powers. The main reason for this is quite simple: Africa is the final frontier as far as the world's supplies of energy are concerned with global competition for both oil and natural gas (particularly the latter) becoming just as intense - if not even more so - than the former. World oil production is only just meeting world demand and old fields are being drained faster than new production can be brought on line. Supplies will be tight for the foreseeable future, so any new source of supply is significant. Most importers are also trying to reduce their dependence on Middle Eastern oil. In the next 10-15 years, most of the new oil entering the world market is going to be coming from African fields because it is only in Africa - and to a lesser extent in the volatile Central Asia region - that substantial new fields have been found and brought into production. This paper summarizes these issues and can be procured at http://www.roape.org/108/08.html.

Strategic Importance

Mills, G. "Africa's New Strategic Significance," The Washington Quarterly, Vol 27, No 4, Autumn 2004 (157-169)

The paper analyzes Washington's recognition of the post-9/11 need for African stability has created a unique opportunity for increased assistance and for realizing the New Partnership for Africa's Development program's ambitious goals of enabling Africa's stability, prosperity, and renaissance. This paper can be procured at http://muse.jhu.edu/login?auth=0&type=summary&url=/journals/washington_quarterly/v027/27.4mills.html

Terrorism

Adan, Hared H., "Combating Transnational Terrorism in Kenya," A thesis presented to the Faculty of the U.S. Army Command and General Staff College in partial fulfillment of the requirements for the degree MASTER OF MILITARY ART AND SCIENCE General Studies, Fort Leavenworth, Kansas, June 17, 2005, http://www.dtic.mil/dtic/tr/fulltext/u2/a436675.pdf

This thesis examines the Kenyan government's (GoK's) increasingly responsive strategy, and its implementation, in combating transnational terrorism focusing on the case studies of the 1998 US Embassy bombing and the 2002 terrorist attacks in Mombasa, Kenya. The analytical research methodology used is qualitative case study. It identifies the factors regarding why terrorists targeted Kenya, how Kenya reacted, and the perceived improvements in Kenya's response to these attacks. Deeper analysis is done by means of analyzing Kenya's use of the instruments of power in its war on terrorism. They are identified and assessed, based on the two case studies, through the submission of questionnaires to independent experts knowledgeable on Kenya's fight against transnational terrorism. The analysis of the response indicates that the Kenyan government was moderately effective in employing the instruments of power between 1998 and 2001. After the 2002 terrorist attacks, it more effectively applied the instruments of power to mitigate the threat and developed a comprehensive national strategy against transnational terrorism. The conclusion of this study is that while the Kenyan government's counterterrorism strategy is becoming increasingly more effective in combating transnational terrorism in terms of the strategy's ends and ways, it falls short of applying the appropriate means in reducing the underlying conditions that make Kenya an easy target for terrorist acts. Recommendations, both short-term and long-term, are proposed to assist the GoK in conducting an even more effective counterterrorism strategy.

Eshel, David. "Defense Update News Analysis: Holy War Inflames Strategic Horn of Africa - by David Eshel," Defense Update - Military and Defense Technology News. Defense Update, 2007, http://defense-update.com/newscast/1206/analysis/analysis-271206.htm, accessed 29 September 2011

This 2007 article discusses the conflict between Somalia's transitional government and Islamic militants that has escalated dangerously, as Islamist leaders threaten Jihad "holy war" against advancing government troops spearheaded by allied Ethiopian forces approaching Mogadishu, held since last June by Somalia Islamic Courts Council (SICC), also named Islamic Courts Union (ICU) alliance. The ICU seized the capital from U.S.-backed

warlords, also taking control of parts of southern Somalia. For months, foreign Islamic radicals have been trickling into Somalia to fight on behalf of the Islamic movement.

Henneke, Jason C., "In What Ways Has US Security Cooperation Programs Been Effective in Helping Kenya to Build Partnership Capacity to Counter Transnational Terrorism," School of Advanced Military Studies United States Army Command and General Staff College Fort Leavenworth, Kansas, March 30, 2007, http://www.dtic.mil/dtic/tr/fulltext/u2/a470674.pdf

This monograph uses Kenya as a case study to analyze the US Security Cooperation role and process in building host-nation capacity to meet the needs of Kenya to counter transnational terrorists' networks. US counterterrorism operations since 9/11 have explicitly demonstrated the US requirement to take an indirect approach to ensuring national security as part of an international community combating transnational terrorists' networks. In addition to capacity building, regional focus from all agencies with the US Government (USG) is required for a coordinated and effective approach in the GWOT. The United States began formal relations with Kenya in 1981 with air and port basing agreements. Kenya's strategic location facilitated access for stability and humanitarian operations in the western Indian Ocean and east Africa. The events of 9/11 highlighted the US requirement for security partners in combating transnational terrorists and Kenya became a central front on the Global War on Terror (GWOT) due to its strategic location and willingness to ally. The partnership that started during the Cold War has carried on through to today's war on transnational terrorists. Kenya is one of the three "anchor states" in sub-Saharan Africa, along with Nigeria and South Africa, essential in stabilizing Africa

Iyob, Ruth, and Edmond J. Keller. "The Horn of Africa, the US and Security Challenges," UCLA International Institute. UCLA African Studies Center, 30 Apr. 2004. Web. http://www.international.ucla.edu/africa/grca/publications/article.asp?parentid=107620, accessed 29 Sept. 2011

The purpose of this publication is to critically assess, the respective interests of both the United States and the countries of the Horn of Africa region and the interrelationships that have historically grown out of those interests. In addition, the essay attempts to show how the forces of globalization have affected those interests (particularly international terrorism and regional security needs, the national/regional nutritional and human security crises relating to food, water, environmental insecurity). Rather than organizing the discussion into discrete country sections, as much as possible, we attempt to approach our topic in a comparative manner. We conclude with a discussion of the implications of the current state of affairs, particularly as this relates to the Horn of Africa and US involvement in the region. Note that the author has called this a draft and not ready for quotation. However, it does contain some good information on the politics of the Horn of Africa.

Wilke, Sharon. "Combating Terrorism in the Horn of Africa and Yemen," Harvard - Belfer Center for Science and International Affairs. Report for Program on Intrastate Conflict, March 2005, http://belfercenter.ksg.harvard.edu/publication/2110/combating_terrorism_in_the_horn_of_africa_and_yemen.html, accessed 28 September 2011

Al Qaeda operatives and sleepers in this region are few, but dangerous. Additionally, there are cells linked both loosely and more tightly to Al Qaeda throughout the region, and beyond into Kenya, Tanzania, and the Comoros. Those cells need to be found and eradicated through concerted diplomatic, intelligence, law enforcement, and military means. Since internal conflict is a constant in this region, Al Qaeda may also embrace or be embraced by the many current insurgent operations or warlords within the individual countries. The threat to U.S. national security and counterterrorism interests, to U.S. and coalition embassies and interests, and to the established governments of the region, is thus as much medium and long term as it is immediate. U.S. efforts to eliminate sources of terror in this region should focus on strengthening national governance and governmental capabilities, strengthening security and counterterrorism capacities, building and maintaining infrastructure, creating jobs, improving education, and attempting to support local efforts to embed the rule of law.

Wise, Rob, "al shabaab," Center for Strategic and International Studies, Homeland Security & Counterterrorism Program Transnational Threats Project, Case Study Number , July 2011, accessed at http://csis.org/files/publication/110715_Wise_AlShabaab_AQAM%20Futures%20Case%20Study_WEB.pdf

Al Shabaab is an al Qaeda-affiliated organization that has risen rapidly to prominence in the midst of Somalia's decades-long anarchy. The group has experienced two dramatic transformations in its short history. Originally the small, youth militia arm of a relatively moderate Islamist organization that rose to power in Somalia in early 2006, al Shabaab was radicalized and brought to prominence as a popular Islamist guerilla movement by Ethiopia's invasion

in December of that year. However, since early 2008 al Shabaab has undergone yet another transformation, this time from a largely nationalist organization focused on driving out Ethiopia through conventional military means to a hybrid movement that has increasingly embraced transnational terrorism and attempted to portray itself as part of the al Qaeda-led global war against the West.

A.1.2 Complex Systems

System Dynamics – Miscellaneous

Grynkewich, A. and C. Reifel. "Modeling Jihad: a System Dynamics Model of the Salafist Group for Preaching and Combat Financial Subsystem," Strategic Insights, Center for Contemporary Conflict, Naval Postgraduate School, November 2006
http://www.nps.edu/Academics/centers/ccc/publications/OnlineJournal/2006/Nov/grynkewichNov06.html

This paper will describe the authors' efforts to model the financial operations and organizational behavior of the Salafist Group for Preaching and Combat (known by its French initials, GSPC), using Stella® version 9.0, a commercially-available system dynamics software package. The model aggregates empirical knowledge and collective expert opinion on the GSPC financial subsystem into a single cognitive tool. Using the model for exploratory analysis suggests answers to questions such as how funding affects the quantity and type of GSPC operations, how the financial and operational aspects of the organization change over its life cycle, and what policymakers should expect next from the GSPC. Finally, the model allows users to see the full range of effects from different policy choices, including effects policymakers may not intend.

Lofdahl, C. L., *Environmental Impacts of Globalization and Trade: A Systems Study.* Cambridge, MA: MIT Press, 2002

This textbook uses systems dynamics to examine the relationship between trade and the environment. This increasing contentious issue between economists and environmentalists is complex and can best be studied using causal theory and system dynamics. This book can be procured at Amazon.

System Dynamics - Nation Modeling

Choucri, N., D. Goldsmith, S. E. Madnick, D. Mistree, J. B. Morrison, and M.D. Siegel. "Using Systems Dynamics to Model and Better Understand State Stability," MIT Sloan School of Management (Working Paper 4661-07), 1 July 2007 pp 1-42, accessed at
http://www.systemdynamics.org/conferences/2007/proceed/papers/MADNI289.pdf

The world can be complex and dangerous - the loss of state stability of countries is of increasing concern. Although every case is unique, there are important common processes. This research presents a system dynamics model of state stability based on an extensive review of the literature and debriefings of subject matter experts. We represent the nature and dynamics of the 'loads' generated by insurgency activities, on the one hand, and the core features of state resilience and its 'capacity' to withstand these 'loads', on the other. The challenge is to determine when threats to stability override the resilience of the state and, more important, to anticipate conditions under which small additional changes in anti-regime activity can generate major disruptions. With these insights, we can identify appropriate and actionable mitigation factors to decrease the likelihood of radical shifts in behavior and enhance prospects for stability.

Sauser, B., Mansouri, M., and Omer, M. "Using Systemigrams in Problem Definition: A Case Study in Maritime Resilience for Homeland Security," Journal of Homeland Security and Emergency Management, The Berkeley Electronic Press, Vol 8, No 1, 2011, accessed at http://www.stevens-tech.edu/csr/fileadmin/csr/Publications/IEEEXplore-7.pdf

Maritime Transportation System (MTS) is a critical infrastructure system that enables economic activity through transferring goods between national and international destinations. This research is an effort to define and view MTS as a System of Systems (SoS) and apply Systems Thinking to understand, engineer, analyze, and govern it in a more effective and efficient way. We define Maritime Transportation System of Systems (MTSoS) as an integration of interdependent constituent systems and apply systemic tools such as Systemigrams to study critical properties of the system such as resilience and security through understanding its systemic interrelationships more effectively. A variety of systems engineering models have been applied to MTS. However, it is necessary to form a structured

approach and develop new systemic toolsets that enables the stakeholders to view interdependencies and interconnections among the constituent systems of MTSoS.

Shanshan, Dai, Li Lanhai, Xu Honggang. "The System Dynamic Study of Regional Development of Manas Basin Under the Constraints of Water Resources," Sun Yat-sen, University, Guangzhou, Guangdong, China, (2009): pp 1-17, http://www.systemdynamics.org/conferences/2010/proceed/papers/P1187.pdf

The arid Manas River Basin, Xinjiang, China, similar to the other arid regions is facing the problem of water constraints. The social, economic and political systems the basin is located in all have to interact with the water resource management. Within the social economic and political systems, growth and expansion has always been the key driving force while it occasionally is forced to slow down or even decline due to the water constraints. To date, the growing populations, industry and agriculture water demand has largely been met by improving and expanding reservoir capacity, by mining fossil groundwater resources, and by improving the water use efficiency. However, bringing future demand in line with available supplies will require increasingly efficient water management practices and greater conservation of water resources. This research paper presents an object-oriented system dynamics approach has been used to develop a model to evaluate the sustainability of the water resource system in the Manas River basin. The study shows that the technical solutions on the improvement of water supply and the improvement of water use efficiency are not the fundamental solutions. Acknowledging the water capacity and changing a growth orientated value system is crucial in the sustainability of Manas River Basin.

Systemigrams - Overview

Blair, C. D., J. T. Boardman, and B. J. Sauser. "Communicating Strategic Intent with Systemigrams: Application to the Network-Enabled Challenge," Wiley InterScience, March 2007, pp 1-14, http://www.boardmansauser.com/downloads/2007BlairBoardmanSauserJSE.pdf

The U.K. Ministry of Defense (MoD) has mandated the development of a network-enabled capability (NEC) across all of defense, aimed at producing agile military and nonmilitary effects via a network of networks. This paper provides an overview of NEC, representing it as a complex human activity system of systems (SoS), analysis of which cannot rely on purely traditional reductionist engineering approaches, requiring instead a soft-systems engineering approach. A literature review is then provided, covering nontraditional systems methodologies of the past 25 years, highlighting the more recent trend towards multi-methodological practice. The paper introduces the systemic diagram, or Systemigram, conceptual model, explaining its evolution from a form of visual language to its use as an appreciative learning system in a soft-systems methodology. Using the written prose of MoD policy makers, a Systemigram model is constructed which represents the NEC concept, providing a systemic visualization of its complexity and an elucidation of the key SoS attributes of emergence, hierarchy, and boundary. Finally, the NEC Systemigram is used in an example storyboarding technique, demonstrating its utility as a platform for stakeholder dialog leading towards a refined model that reflects a deeper understanding of NEC strategy.

Boardman, J., and Sauser, B. A., Systems Thinking: Coping with 21st Century Problems. Boca Raton, FL: CRC Press, 2008

This book features a holistic, nonlinear way of looking at systems, this book helps readers better organize and structure their thinking of systems in order to solve complex, real-world problems. This includes but is not limited to incorporating new systems concepts, patterns of thinking, and examples from a range of domains, including technology development, engineering, business management, the intelligence community, and policies, presenting the use of Systemigrams (a unique form of system diagramming that aids companies in their thinking of major endeavors), and discussing system of systems (SoS) in terms of the authors' original research on various defense and space projects.

System Dynamics - Terrorism Studies

Gil, Benigno, Masahiro Matsuura, Carlos Molina Monzon, and Ioannis Samothrakis. "The Use of System Dynamics Analysis and Modeling Techniques to Explore Policy Levers in the Fight Against Middle Eastern Terrorist Groups," Naval Postgraduate School, Monterey, California, (2005): pp 1-81, accessed at http://oai.dtic.mil/oai/oai?verb=getRecord&metadataPrefix=html&identifier=ADA435682

The objective of this project is to use analysis and modeling techniques from Systems Dynamics to capture the causal relationships of Middle Eastern groups' terrorist activities against the United States based on their ideological drivers, as well as the effect of U.S. policies that create dynamics and affect performance and outcomes. The main

focus of the analysis is the terrorist groups' human resources. The hypothesis is that Middle Eastern terrorism against the U.S. is affected by the U.S. level of military presence and/or investment in the Middle Eastern nations. A considerable and lasting reduction in fatalities originated by Middle Eastern groups' terrorist attacks against the United States can be achieved through a policy that reduces both the human resources available to terrorist groups and their attack capability (level of sophistication). The study covers the implications of this resource reduction policy, which may include incremental military investment, defection motivators, anti-terrorism, and the use of counterterrorism operations. These operations will reduce the sophistication as well as the recruitment rate to levels where the functionality of terrorist cells will be impaired, and thus unable to carry out high lethality attacks.

A.2 Model Data Sources

Country Capacity		
Data	**Figure**	**Source**
Budget for schools	$1,022,417,344	
Cost to Create a school	$12,500	
Time to increase literacy rate	1	
Time to decrease literacy rate	50	
Time to increase average grade level		
Impact of average grade level		
Impact of literacy rate on education		
Fractional Increase in population	2.44%	
# of years being reviewed		
Percentage of population with HIV	6.30%	
Impact of Net deaths		
Deaths per year as percentage population	0.73%	
Natural time to degrade access to capital		
Effect of access to capital per dollar decrease		
Time to Decrease country capacity		
Time to increase country capacity		
Multiplier of Population with Country capacity		
Average Grade Level	11 years	
Population	43013341	
Literacy Rate	85.10%	
Essential Services		
Data	**Figure**	**Source**
Time for Medical services to Degrade		
Cost of hospital service	$18,4757,000	http://www.gtzkenyahealth.com/blog3/wp-content/uploads/2010/07/Health-Budget-Analysis_FINAL.pdf
% medical budget for hospitals (good)	37%	http://www.gtzkenyahealth.com/blog3/wp-content/uploads/2010/07/Health-Budget-Analysis_FINAL.pdf
% budget for GSS	48%	http://www.gtzkenyahealth.com/blog3/wp-content/uploads/2010/07/Health-Budget-Analysis_FINAL.pdf
% budget for roads	52%	http://www.gtzkenyahealth.com/blog3/wp-content/uploads/2010/07/Health-Budget-Analysis_FINAL.pdf
Costs for GSS	$528,800,000	http://www.gtzkenyahealth.com/blog3/wp-content/uploads/2010/07/Health-Budget-Analysis_FINAL.pdf
% budget to road	22%	http://www.gtzkenyahealth.com/blog3/wp-content/uploads/2010/07/Health-Budget-Analysis_FINAL.pdf
Costs of road service	$3,120,058	http://www.gtzkenyahealth.com/blog3/wp-content/uploads/2010/07/Health-Budget-Analysis_FINAL.pdf
Time to build road km/month	4.215	http://www.gtzkenyahealth.com/blog3/wp-content/uploads/2010/07/Health-Budget-Analysis_FINAL.pdf
Budget to medical service	$500,600,000	http://www.gtzkenyahealth.com/blog3/wp-content/uploads/2010/07/Health-Budget-Analysis_FINAL.pdf
Cost of medical education	$1,099,735	http://www.gtzkenyahealth.com/blog3/wp-content/uploads/2010/07/Health-Budget-Analysis_FINAL.pdf
% medical budget to education	0.22%	http://www.gtzkenyahealth.com/blog3/wp-content/uploads/2010/07/Health-Budget-Analysis_FINAL.pdf
Time for medical service budget to increase (year)	1	http://www.gtzkenyahealth.com/blog3/wp-content/uploads/2010/07/Health-Budget-Analysis_FINAL.pdf
Total ground water gallons	7.97E+12	https://www.cia.gov/library/publications/the-world-factbook/geos/ke.html
Amount usable surface water gallons	4.17E+11	https://www.cia.gov/library/publications/the-world-factbook/geos/ke.html
Required amount of water gallons	1.25E+11	https://www.cia.gov/library/publications/the-world-factbook/geos/ke.html
Foreign water aid service	3.026E+11	http://www.wateraid.org/uk/about_us/frequently_asked_questions/our_work/wateraids_new_country_programmes/7994.asp#6
Time to supply water(hours)	14	http://en.wikipedia.org/wiki/Water_supply_and_sanitation_in_Kenya

Economics		
Data	**Figure**	**Source**
Working age population	18,390,000	http://www.theodora.com/wfbcurrent/kenya/kenya_economy.html
Average wage / salary	$4,812	http://www.payscale.com/research/KE/Country=Kenya/Salary
International Investments	$3,012,400,000	
Unemployment Rate	40.00%	
Time for Unemployment Rate to Change	3 years	http://www.indexmundi.com/g/g.aspx?c=ke&v=74
Previous Year's Average Household Income	$8,160	
Average # of Working Age Adults per Household	2.8101	
Government Investment	$14,729,000,000	
Private Consumption of Goods	$37,655,641,432.37	http://www.tradingeconomics.com/kenya/household-final-consumption-expenditure-ppp-us-dollar-wb-data.html
Commodities Exported	$5,443,000,000	
Population in Service Sector	10,753,335	
Income per Person in Technology sector	$15,367	http://www.payscale.com/research/KE/Country=Kenya/Salary
Education Level	11 years	
International Loans' Interest and Payments	$321,400,000	https://www.cia.gov/library/publications/the-world-factbook/geos/ke.html
National Debt	$34,677,500,000	
Total Imports as % of GDP	0.166	
Time to Change GDP	3 months	
Current GDP (Purchasing Power Parity)	$71,500,000,000	https://www.cia.gov/library/publications/the-world-factbook/geos/ke.html
Potential GDP	$1,507,500,000,000	

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Department of Systems Engineering
United States Military Academy
West Point, New York 10096
www.nrcd.usma.edu