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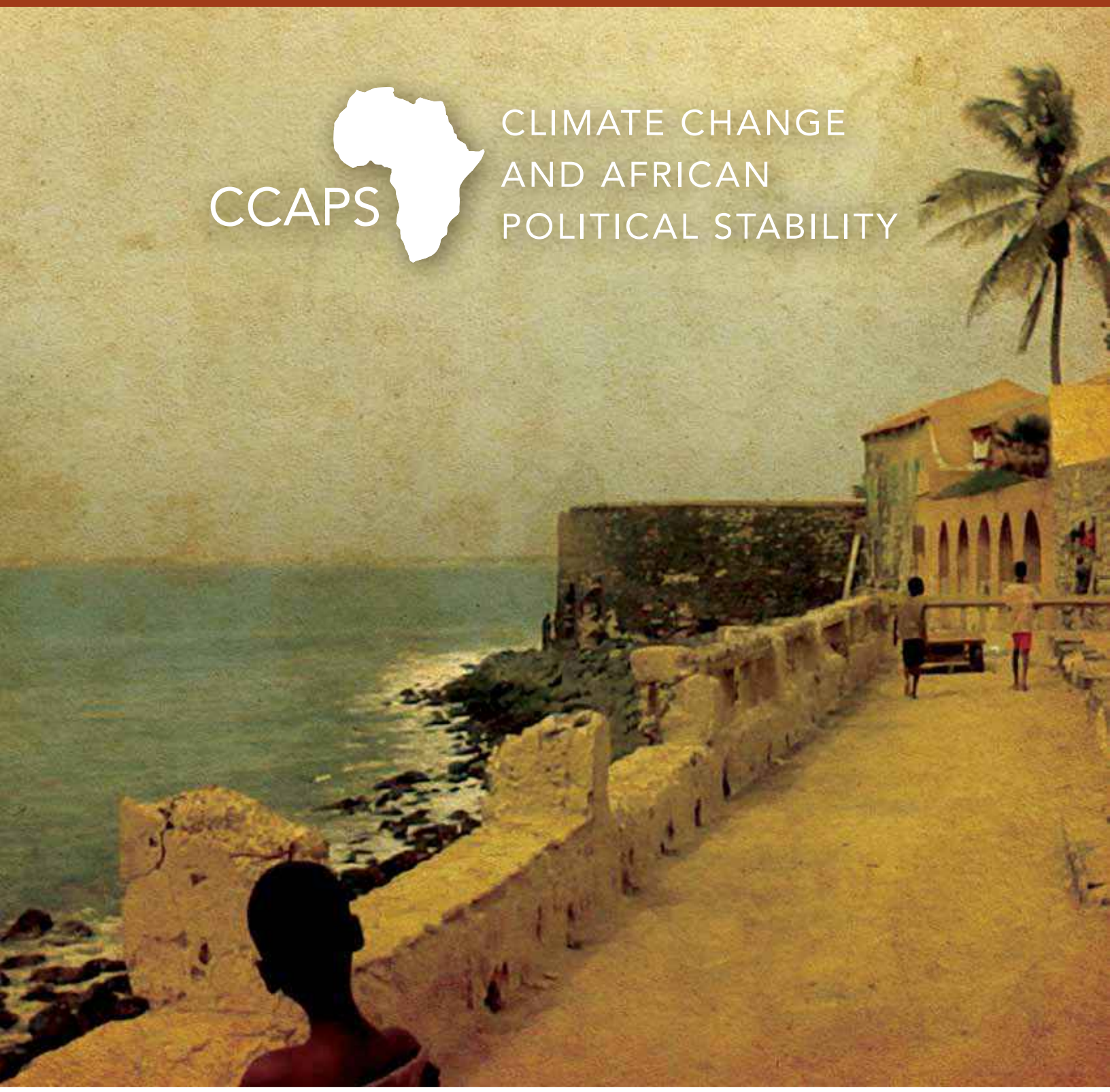
CCAPS

CLIMATE CHANGE AND AFRICAN POLITICAL STABILITY



VULNERABILITY TO CLIMATE CHANGE IN WEST AFRICA:

Adaptive Capacity in the Regional Context

STUDENT WORKING PAPER NO. 4

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Edited by Dr. Joshua W. Busby, Kaiba L. White, and Todd G. Smith

ABOUT THE CCAPS PROGRAM

This paper is produced as part of the Strauss Center's program on Climate Change and African Political Stability (CCAPS). The program conducts research in three core areas, seeking to investigate where and how climate change poses threats to stability in Africa, identify strategies to support accountable and effective governance in Africa, and evaluate the effectiveness of international aid to help African societies adapt to climate change. The CCAPS program is a collaborative research program among the University of Texas at Austin, the College of William and Mary, Trinity College Dublin, and the University of North Texas.

The CCAPS program is funded by the U.S. Department of Defense's Minerva Initiative, a university-based, social science research program focused on areas of strategic importance to national security policy. Through quantitative analysis, GIS mapping, case studies, and field interviews, the program seeks to produce research that provides practical guidance for policy makers and enriches the body of scholarly literature in this field. The CCAPS team seeks to engage Africa policy communities in the United States, Africa, and elsewhere as a critical part of its research.

ABOUT THE STRAUSS CENTER

The Robert S. Strauss Center for International Security and Law at The University of Texas at Austin is a nonpartisan research center that engages the best minds in academia, government, and the private sector to develop unique, policy-relevant solutions to complex global challenges.

ABOUT THE AUTHORS

Emily Joiner, Derell Kennedo, and Jesse Sampson wrote this paper as Master of Global Policy Studies students at the LBJ School of Public Affairs. This graduate student work is based on collaboration with CCAPS researchers as part of a year-long Policy Research Project course on climate change and security in Africa at the LBJ School of Public Affairs. The course was led by Dr. Joshua Busby in the 2009-10 academic year. Authors are listed in alphabetical order.

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Predicting the future impacts of climate change is a difficult business. Even determining the future physical effects is fraught because of the complexity of the Earth's climate system and the imperfections of current climate models. In addition, while some places may have less physical exposure to climate change risk than others, their lack of resources for adaptation projects or other factors such as a history of ethnic conflict may render them more vulnerable. Vulnerability has two components, then: physical exposure and adaptive capacity.

It is commonplace in the discourse on global climate change to say that Africa will be the most vulnerable location worldwide, because of poverty, environmental degradation, and conflict. However, Africa is a large and diverse continent. To make meaningful contributions to the policy debate on Africa it is insufficient to say, "Africa will be vulnerable to climate change;" researchers must determine which areas in Africa will be vulnerable and for what reasons.

This paper builds on the climate change vulnerability mapping work of the Robert S. Strauss Center on International Security and Law's Climate Change and African Political Stability (CCAPS) program. The CCAPS program takes data on climate-related hazard exposure, population density, and the adaptive capacity of governments and households, and uses Geographic Information Systems (GIS) software to identify the areas of highest composite vulnerability. This paper applies the CCAPS methodology to West Africa to investigate vulnerability at the sub-regional level rather than the continental level. Since West Africa has unique climate characteristics and historical climate data for the region are limited, global climate models do not capture regional weather patterns effectively. For this reason, this paper's primary addition to the model is in the area of adaptive capacity.

This paper expands on the CCAPS vulnerability index by incorporating new data related to the political economy of governments as it may relate to their willingness and ability to adapt to climate change. Specifically, it adds dependence on oil and mineral extraction and ethnic and religious diversity to measures of governance. These variables have a unique role in the political dynamics of the West Africa region. Moreover, the negative effect they have on governance takes place independent of changes in leadership or political structure, making them superior forecasters of governance quality. We further expand on the CCAPS program by exploring different mapping techniques such as difference mapping and cluster analysis. The paper concludes with two country case studies on Nigeria and Guinea-Bissau, which both consistently rank among the most vulnerable places according to our vulnerability index.

With the addition of our new oil and mineral dependency and ethno-religious diversity variables, two countries appear more vulnerable than in previous estimations: Nigeria (particularly northern Nigeria) and Côte d'Ivoire. Meanwhile, cluster analysis indicates that the highest concentration of vulnerability is located along the West African coast in areas with high ethnic and religious diversity. Incidentally, these countries also share a history of civil and ethnic conflicts. These areas include Nigeria's Niger Delta, Liberia, Sierra Leone, and Guinea-Bissau.

Policy and research implications of this analysis include:

- *Supporting research into better metrics for governance and adaptive capacity.*
- *Illustrating a need to improve the granularity of climate models.*
- *Considering the role of governance in adaptive capacity when crafting policies to respond to climate change in Africa.*
- *Focusing data collection and monitoring efforts on the most vulnerable areas, defined as areas with persistently high vulnerability scores across a variety of vulnerability index constructions.*

INTRODUCTION

In June 2009, unusually heavy seasonal rains began to fall in West Africa. By September, 16 countries faced widespread floods and at least 600,000 people had lost food, homes, or livestock due to the continuing rains. Hospitals, roads, dams, and schools were destroyed by floodwaters as the Volta, Senegal, and Niger rivers overflowed their banks. Senegal, Sierra Leone, Ghana, and Benin were among the countries most affected; however, the United Nations World Food Programme (WFP) estimated that the floods in Burkina Faso were the worst experienced in that country in 90 years. In Ouagadougou, the Burkinabi capital city, at least 150,000 people were affected. The United Nations Office for the Coordination of Humanitarian Affairs (OCHA) and WFP coordinated their response to the disaster, along with the World Health Organization (WHO) and other international organizations. By mid-September, WFP committed to providing food to 177,500 people, and WHO monitored the situation for outbreaks of infectious disease. Meanwhile, OCHA released statements linking the disaster to the effects of climate change, specifically increased variability in seasonal rainfall – unusually dry weather followed by unusually heavy rains.[1]

The United States Agency for International Development (USAID) report on the crisis describes a cooperative effort between governments and aid agencies to help people recover from the disaster. In Senegal, the government helped transport drinking water to affected regions of the country, and the government of Burkina Faso assisted in the relocation of families displaced from their homes. Elsewhere, governments helped direct the distribution of aid and emergency health care supplies.[2] While by no means comprehensive, these reports indicate an important characteristic of disaster recovery – government capacity to directly assist the population and government willingness to work with foreign aid organizations to fill gaps in government capabilities in equitable ways. At the same time, the reports underscore that the baseline income, economic activities, and infrastructure available to populations affected by extreme weather events will determine whether physical exposure to a climate-related hazard will lead to a disaster.

Policymakers and scholars alike note that Africa faces unique challenges for coping with climate change due to its geography, its dependence on rain-fed agriculture, and the fragile social and political infrastructure of many of the continent's countries. Nevertheless, uncertainties about the specific effects of climate change abound. Climate scientists labor to develop consistent models for projecting new climate scenarios outside of historical parameters. Meanwhile, political scientists grapple with the implications of these scenarios for African governments working to manage the changes effectively to avoid conflict or humanitarian disaster. After the 2009 Copenhagen climate conference, the difficulty of achieving international cooperation to mitigate climate change has prompted many policymakers to increase their focus on strategies to help affected countries adapt to its effects. However, the question of where and to whom adaptation measures should be targeted remains complex in the face of so many political and scientific uncertainties.

This paper builds upon ongoing research efforts by the Climate Change and African Political Stability (CCAPS) program underway at the Robert S. Strauss Center for International Security and Law. The CCAPS program has endeavored to use GIS to analyze where the regions of greatest vulnerability may be found on the African continent, both across and within countries, where possible. This work provides an analysis of vulnerability that policymakers can use to target strategies for adapting to climate change and assisting populations with the greatest need for assistance in the face of slow- or rapid-onset climate-related events. In addition, GIS allows different types of data on multiple indicators to be represented as maps for step-by-step analysis of each factor's contribution to measures of climate change vulnerability.

Composite vulnerability, as defined by the CCAPS program team, is an index of the relative vulnerability to climate change impacts in a given area.[3] The original components of the CCAPS composite index measure physical exposure to climate change impacts and the capacity of governments and populations to respond. The four areas incorporated into this model include the physical exposure of a region to climate-related hazards ("climate hazards"); population density; household access to food, clean water, healthcare, and education ("household vulnerability"); and the quality of governance ("governance"). Each of these factors received equal weight in the final calculation of "composite vulnerability."

This paper focuses on adapting the CCAPS vulnerability index to the unique characteristics of the West Africa region. In building a revised model, the research team concentrated on the importance of government capacity to respond to climate change and the role of mineral resources and ethnic and religious diversity in determining how governments choose to allocate resources for adaptation or disaster assistance. To begin, the paper describes the West African context with regard to governance, cultural demographics, and likely climate impacts. The paper then describes the links between these three factors and the methodology for incorporating them into a new model for calculating relative climate change vulnerability in West Africa. The impacts of the new variables are analyzed on a regional and continent-wide basis, and case studies of Nigeria and Guinea-Bissau delve further into the socio-political factors at work in these West African countries. Finally, the paper concludes by describing the implications of this new model for measuring climate change vulnerability and identifying areas for further research.

PART 1: THE WEST AFRICAN CONTEXT

For the purposes of this study, West Africa includes the coastal portions of the African continent from Senegal to the Republic of the Congo (ROC), including Burkina Faso and the Central African Republic (CAR). It excludes the countries of the Sahel from Mauritania to Chad, which are sometimes included in the region (see Figure 1). This grouping emphasizes certain commonalities among the countries. For instance, these countries are located within the savanna and forested regions of West Africa, with only a small portion of Senegal and northern Nigeria located in the steppe grasslands. As a result, the countries in the region face many of the same climate change effects. This region has a very rich and diverse ethno-linguistic and religious composition, as well as vast mineral, oil, and gas deposits. These characteristics have made stable and effective governance difficult as the region has coped with conflicts over ethnic power relations and control of important natural resources.

West Africa's geography has played an integral role in shaping its cultural demographics. Abundant dense forests make the region an ideal location for the formation of distinct ethnic groups due to the difficulties of travel and communication across this landscape. Nigeria and Cameroon each have more than 250 ethnic groups, while Ghana has more than 100 ethnic groups. These examples are not atypical: every country in the region contains dozens of ethnic groups. At the same time, an important dynamic in each country from Côte d'Ivoire to Cameroon is a north-south divide between Muslim and Christian religious groups. For over 1,000 years Islam has spread south from northern Africa into western Africa, but it was largely halted by the dense tropical forest. During the past 500 years, Europeans had contact with coastal populations and spread Christianity northwards until it was halted by Islam.[4] This divide is evident in the religious distribution in West Africa (see Figure 2). Religious and ethnic diversity has, in many places, created tensions as the various groups compete for control of resources. Civil wars, localized violence, and political conflicts in the region have often occurred across ethnic or religious lines, such as the 2002 coup in Côte d'Ivoire and recurrent coups in Nigeria over the past 25 years.[5]

Figure 1

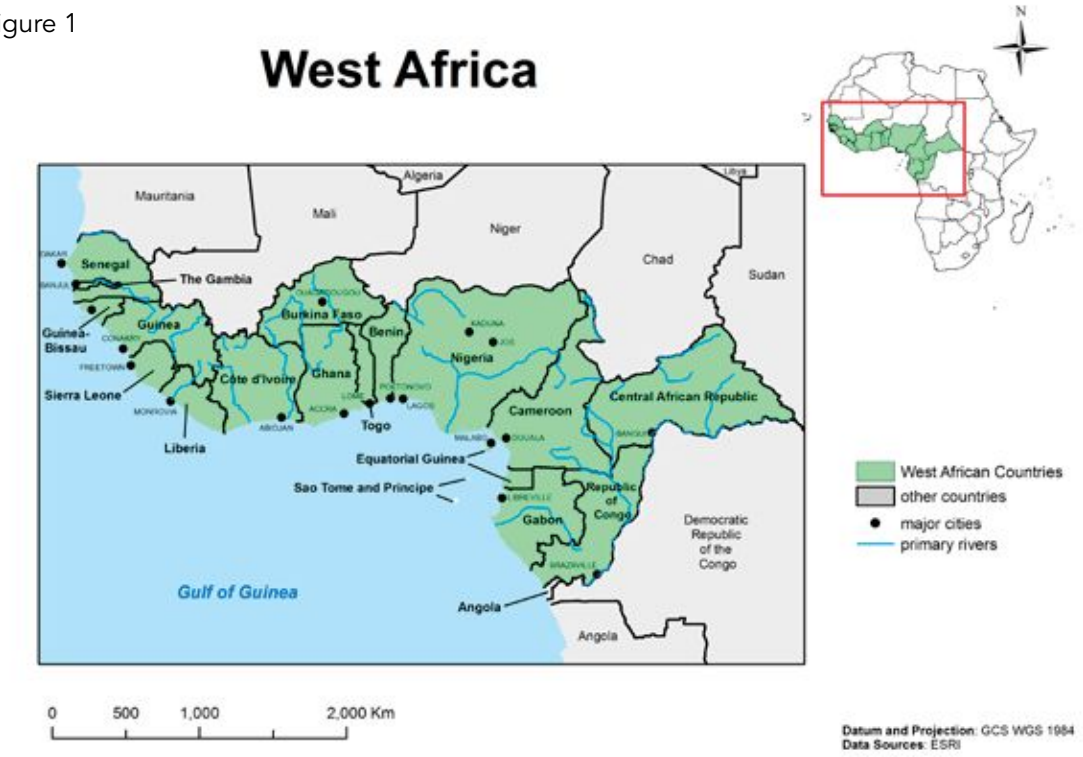
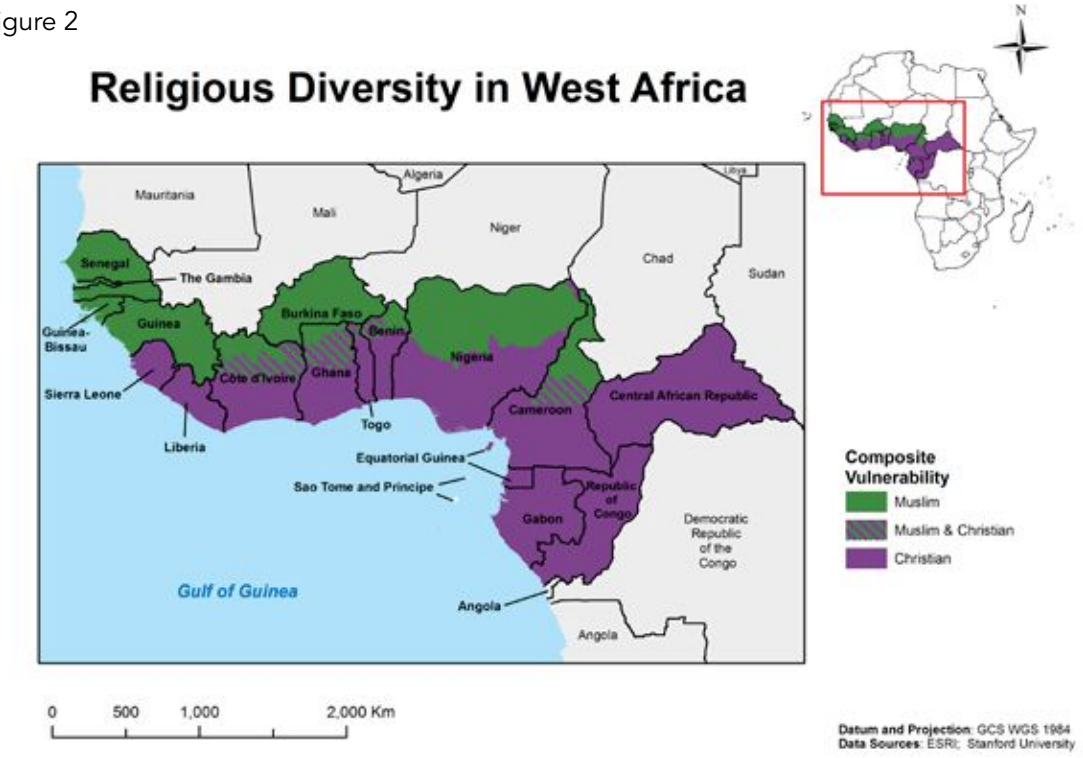
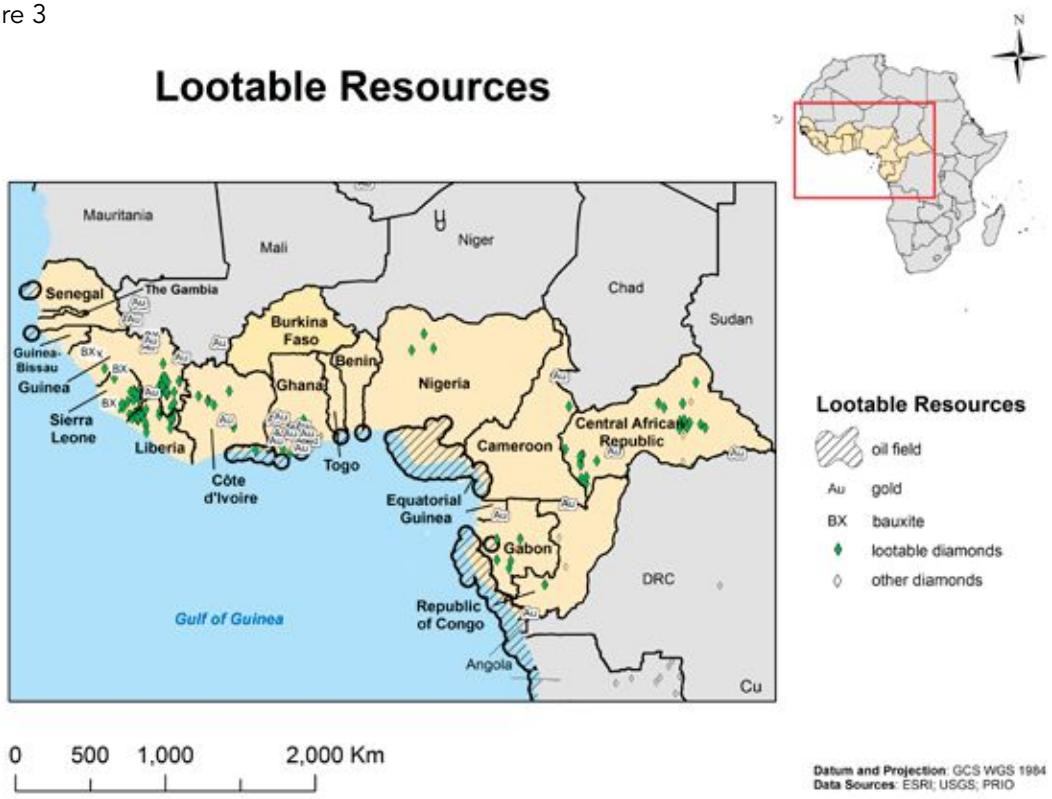


Figure 2



West Africa possesses an abundance of minerals and other natural resources (see Figure 3). The Gulf of Guinea is particularly rich in oil and natural gas deposits, and the countries stretching southward on the West African coast from Nigeria to the ROC depend on the exploitation of oil for government revenue.[6] The region supplied 10.7 percent of U.S. crude oil imports in 2010, and Nigeria alone accounted for 8.7 percent.[7] In addition to the diamonds found in Sierra Leone, several key minerals can be found in West Africa. Guinea is the world's fifth-largest producer of bauxite and has the world's largest proven reserves of this mineral.[8] Ghana is also the world's tenth largest and African's second largest gold producer (after South Africa).[9]

Figure 3



West Africa's mining industry represents only a small portion of global trade in minerals; however, rich, untapped reserves exist in many countries. Conflict has contributed to the lack of mining development. Profitable oil extraction requires large amounts of capital and the ability to transport and market crude petroleum. However, mining is possible, though inefficient, at the artisanal level with crude implements and little capital. Therefore, armed groups have fought for control of these minerals in order to enrich themselves or fund other activities. This has made mining a generally destabilizing force in the region, rather than a source of development funding for public works such as climate change adaptation measures. In addition, extractive activities of all types have been linked to varying degrees of local environmental degradation that may increase the population's vulnerability to climate change.

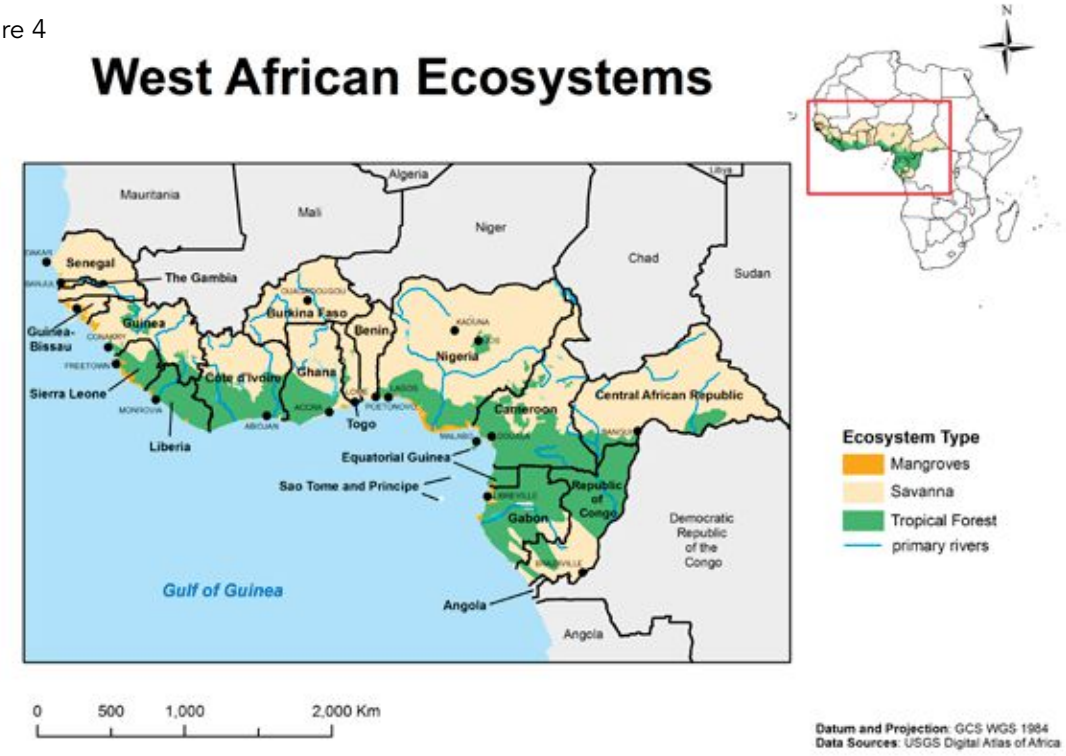
The Intergovernmental Panel on Climate Change (IPCC) in 2007 projected that West African countries would face several distinct challenges from climate change. Since the 1960s, rainfall across West Africa decreased by approximately four percent per year, even while a ten percent increase has been noted along the Guinean coast.[10] Projections of changes to precipitation in West Africa vary widely; however, rainfall variability will continue to be a major concern for the region as countries cope with more extreme seasonal droughts in the north and floods in the south.[11] Droughts have been common throughout West African history and in the last ten years have taken a substantial toll on the livelihoods and food security of hundreds of thousands of people.[12]

As precipitation increases in some areas and decreases in others, West African populations will become increasingly vulnerable to these changes due to their reliance on climate-dependent economic activities such as agriculture, herding, and fishing.[13] Most West Africans are subsistence farmers. They practice rain-fed agriculture and depend on stable weather patterns to make planting and harvesting decisions. Unpredictable weather patterns will increase farmers' vulnerability to failed crops and hunger or poverty. A significant proportion of the West African population is herders. Herders depend on stable weather to keep the soils healthy enough to grow grasses to feed their cattle. They are particularly vulnerable to drought because herders tend to reside in relatively dry areas. Attempts by governments to limit the mobility of pastoralists, coupled with the drying of the Sahel region, have been identified by some observers as a source of conflict in many countries throughout the region.[14] The effects of climate change could lead to unstable livelihoods and the potential for increased political instability.

West Africa faces other forms of vulnerability including sea level rise and deforestation. The sea level is rising as ocean temperatures increase, and urban coastal populations will be particularly vulnerable to these changes. National governments will face challenges in protecting densely populated coasts from becoming inundated and protecting livelihoods as saltwater intrusion changes the composition of agricultural land and destroys fisheries. Already, 40 percent of West Africa's population is concentrated in coastal cities vulnerable to sea level rise, and the IPCC estimates that by 2020 more than 50 million people will inhabit the coast from the Niger delta in Nigeria to Ghana's capitol city, Accra.[15] The largest city in West Africa—Lagos, Nigeria—is predicted to be especially vulnerable to sea level rise.[16] Another effect of sea-level rise is the destruction of marine ecosystems, particularly mangroves. The Niger Delta in Nigeria and the West African coast from Senegal to Sierra Leone have rich mangrove ecosystems that protect the soils and fisheries (see Figure 4).[17] As sea levels rise, fishermen and farmers will face the destruction of their livelihoods as coastal economies confront changes to their environment and will thus need to adapt their economic activities accordingly.

Meanwhile, continuing deforestation in the region will compound the effects of climate change by increasing erosion and the potential for floods.[18] Since the 1960s, 90 percent of West Africa's forests have been logged, primarily for use as firewood or charcoal, though some forests are cut to facilitate oil extraction and mining activities.[19] Nigeria has experienced particularly rapid deforestation in the past decade, losing as much as 55 percent of its primary forests to logging during this period.[20] Household dependence on wood for fuel will make deforestation a particularly challenging problem for governments to halt.

Figure 4



PART 2: CONTRIBUTIONS OF MINERAL DEPENDENCE AND ETHNO-RELIGIOUS DIVERSITY TO CLIMATE CHANGE VULNERABILITY

The literature on conflict and climate change broadly concludes that poor governance, not environmental change, is the most important driver of instability. However, current indices of governance quality are sensitive to changes in leadership or political structure. This study sought to address this deficiency by including variables that have empirically verified negative impacts on governance, in the interest of using measures that have better predictive power over time. These include ethnic and religious fragmentation and dependence on extractive resources.

Mineral Resource Dependence and Governance

In West Africa, rich natural resources have in some cases contributed to poverty, poor governance, and conflict.[21] By providing a source of substantial, non-tax revenues for the government, oil and mineral resources can change the political calculus of a state. Investment may become concentrated in these low-employment economic sectors, rents may be distributed among a small group of officials or used to maintain control of the government, and states may be able to allocate their resources without accountability to the needs of the population. In the context of climate change, this translates into the potential for governments to under-invest in public goods such as general adaptation measures or humanitarian assistance in the event of a specific extreme weather event. Additionally, the inequitable concentration of economic wealth in a single extractive sector may leave some communities impoverished and less able to cope independently with climate-induced changes to their livelihoods.

The largest oil deposits in Africa lie in the Gulf of Guinea, and many West African states possess large resources of metals and precious stones. In some countries, the extractive industries exert a grossly disproportionate influence on the economy: in Equatorial Guinea, for example, the value of oil and natural gas exports was equal to 97 percent of gross domestic product (GDP) in 2010.[22] In Nigeria, although oil and gas production represent only 37 percent of GDP (2006), it accounted for 40 percent of government revenues.[23] Meanwhile, 70 percent of Nigerians work in the climate-dependent agricultural sector and thus do not benefit from government investment in the oil industry.[24] Minerals play a similar role in countries like Guinea, with bauxite and aluminum exports historically providing about 80 percent of their foreign exchange.[25] Economies dependent on a single extractive industry are more fragile than diverse economies and can face major setbacks from price volatility. Should a government's budget depend on oil or mineral resources, fluctuation in that commodity's price may cause inconsistent or incomplete investment in public goods such as health and education infrastructure or climate change adaptation.

Aside from this basic price fluctuation concern, which is not limited to extractive economies, oil and mineral dependence may exert any of several effects on a country's political economy. For purposes of this analysis, the relevant mechanisms are rentier economy effects on political processes, the so-called "Dutch disease", and the emergence of non-productive entrepreneurship.

Broadly defined, a rentier state is any state that receives large economic rents from a natural resource.[26] Belbawi and Luciani elaborate this definition, emphasizing that for a rentier economy to develop, the source of the profits should be external, thereby freeing the government from the need to extract revenue from the domestic economy through taxation.[27]

Dutch disease is a phenomenon first observed after natural gas discoveries in the Netherlands. In order to pay for increased natural gas exports, foreign buyers had to convert more foreign currency into Dutch guilders. Higher demand made the guilder appreciate. A higher guilder resulted in higher costs for Dutch producers relative to foreign ones, and foreign manufactured goods became more competitive on export markets, causing the decline in other export-oriented sectors, especially manufacturing. In extreme cases of Dutch disease, such as Nigeria, the manufacturing sector starves, resulting in large proportions of the population working in agriculture yet producing a relatively small share of GDP.

With these effects, incentives for what William Baumol calls "non-productive entrepreneurship" increase.[28] Broadly, this means that minimal incentives for productive entrepreneurial innovation (i.e. marketing a new product or service) cause talented people to find creative ways to extract rents from a single productive sector of the economy. As Yates declares in reference to Gabon, the state becomes an "allocation" rather than a "production" state.[29] The state does not have to actively pursue economic policies that stimulate economic growth and produce revenues to fund the government; rather, it dedicates itself to generating revenues from the oil sector and allocates these funds as fits its interests. In other words, the government does not have an incentive to establish policies that support broad economic development, fostering a situation that will result in high levels of inequality and poverty for the population.

The pernicious effects of the rentier economy manifest in many ways. For example, Michael Ross showed that resource dependency negatively impacts political openness and democracy, while Jeffrey Sachs and Andrew Warner show it negatively impacts GDP growth.[30] In addition, leaders can distribute the rents in the form of patronage to secure their positions, contributing to the remarkable longevity of regimes like Omar Bongo's in Gabon or Jose Eduardo dos Santos' in Angola.[31] For these reasons, this study adds a term for extractive resource intensity to the CCAPS index of governance vulnerability to climate change.[32] Since extractive rents allow the state to function without taxing the population, the government can ignore concerns of legitimacy and make fewer investments in development, climate change adaptation, and disaster assistance. In

addition, poorly managed revenue from extractive industries often does not enter the national economy as investment, leading to high unemployment. These factors create a baseline condition of poverty, which makes populations more vulnerable to the increased severity and number of extreme weather events and other stresses climate change is predicted to cause. This outcome is particularly noticeable in West Africa: 11 of the 24 least developed countries identified by the UN's Human Development Index and 12 of the 25 lowest ranked countries on the Human and Income Poverty Index are in West Africa.[33]

Ethnic Polarization, Religious Diversity, and Governance

Ethnic and religious demographics comprise a key component of the initial conditions that affect the governance of any state. In Africa today, members of ethnic groups across the continent continue to speak an estimated 1,000 to 2,000 languages.[34] In addition to this broad ethno-linguistic diversity, the African continent is home to followers of Islamic and Christian religious traditions that coexist alongside a small minority of adherents to traditional African religions. Some have posited that this extreme diversity of ethno-linguistic groups and religious faiths is an explanation for political conflict, poor economic growth, and rent-seeking government practices. For example, Ethiopian Prime Minister Meles Zenawi remarked in a 2000 speech that the ethnic motivation for these governance problems was a hallmark of the African political economy.[35] An extension of this statement would be to state that ethnic groups function as interest groups with varying degrees of power to affect government policy choices.

In this context of ethnic and religious diversity, climate change could act as a vulnerability magnifier on, as Daniel Moran states, "the sinews of social life" in countries where ethnic and religious demographics have historically caused conflict or exclusionary politics.[36] It is important to note that the history of conflict plays a role in whether a community faced with climate change effects that stretch their resources will see a resurgence of inter-ethnic conflict following a slow- or rapid-onset climate event. Additionally, histories of past conflict that undermine social integration and cooperation more generally may result in the exclusion of certain ethnic groups from resource sharing and aid distribution in the face of a climate disaster.

Even more central to this study, development scholars have linked ethnic divisions to both clientelism and reduced overall government investment in social programs and projects. In the case of clientelism, the status of an ethnic group as discriminated or politically irrelevant might prevent its members from receiving adequate resource allocations for adaptation projects to equip their communities to withstand climate change. When marginalized ethnic groups also live in zones of high physical exposure to climate change, the political status of their group could determine the overall impact of climate change on their communities. At the same time, ethnic groups without political power may face increased risk of exclusion from allocations of humanitarian aid following an extreme climate event as political leaders seek to curry favor and care for the needs of their own ethnic community prior to assisting others.

At the national level, the ethno-religious cleavages of a society may decrease the amount of funding governments invest in public goods such as adaptation measures that could help communities of all ethnic backgrounds manage health risks, improve water supplies, or shift economic resources into occupations less dependent on climate inputs such as temperature, sun, and rainfall. In this scenario, the ethno-religious divisions of a society could cause the government to leave its entire population at increased vulnerability to climate change.

Scholars of economic development have conducted numerous analyses linking ethno-linguistic fragmentation of societies with the social, economic, and political performance of countries over

time. And, while little of the existing research on ethnic diversity, economic development, and public good provision singles out religious composition as a facet of ethnic diversity, it is possible this cultural difference could also play a role in the political economy of at least a few African countries. As Figure 2 shows, populations whose religious diversity divides the population into two large subsets cluster along the West African coast and then stretch across the continent through Chad, Sudan, and Ethiopia.[37]

Research into the confluence of economic development and ethnic diversity has indicated that highly fractionalized societies tend to have exclusionist economic policies that prevent all ethnic groups from benefiting equally from growth. In a 1997 study, economist Bill Easterly found that increased ethno-linguistic fractionalization is an empirically verified factor inversely correlated with the income and economic growth rates of African countries.[38] In other words, the more ethnically diverse a society, the slower its economic growth rates will be. Contemporary research extended this finding to conclude that ethnically polarized countries' economic performance showed more dramatic impacts from external shocks to their terms of trade.[39] Other studies indicate that governments of ethnically diverse countries divert large portions of aid and international assistance into the pockets of leaders from the politically dominant group.[40] Meanwhile, some evidence also exists that a government's total investment in public goods consistently decreases with rising heterogeneity in the ethno-religious composition of the society, both in relation to national budgets and local government budgets.[41] These economic effects remain significant even after controlling for the presence of civil wars.[42]

Aside from these social and economic indicators that link closely to general development concerns within a society, ethnic and religious cleavages also play a major role in determining the political stability of a state. In Africa, and particularly in West Africa, ethnic and religious heterogeneity has played a role in political instability and periodic violent conflict. For example, analysis of democracies established since 1960 has demonstrated that countries with higher than average rates of ethnic fractionalization are 13 percent less likely to remain democracies than countries with lower rates.[43] The connections between ethnic heterogeneity and violent conflict have been illustrated in quantitative studies, consistently finding a positive and statistically significant correlation between high ethnic diversity and increased incidence of conflict deaths[44] and the duration of civil conflict.[45] Studies of religious diversity and conflict point to a less clear, occasional linkage between conflict and religious diversity in which religion becomes one of many unifying factors for aggrieved parties. In West Africa, conflicts in Côte d'Ivoire, Liberia, and Sierra Leone have all been couched in religious terms; however, it has also been suggested that ethnic and geographic tensions and competition for scarce jobs were equally important as factors fueling the conflicts.[46]

In light of the varied effects of ethnic and religious diversity on governance, the model presented in this paper incorporates both ethnic and religious diversity into the assessment of "governance" vulnerability to climate change. Therefore, this study employs an ethnic polarization variable that measures the percentage of each country's population belonging to ethnic groups with political representation.[47] This variable is particularly well-suited to the analysis of ethnic diversity in the context of governance, because it takes into account the varied political structures found across the African continent and provides a way to conceptualize how different countries with similar ethnic diversity might reach different outcomes in the face of climate change effects. At the same time, the study also incorporates national data documenting the size of the two largest religious groups in Africa – Muslims and Christians – in order to represent the role of ethnic and religious diversity in climate change vulnerability.

PART 3: METHODOLOGY

The original CCAPS model for measuring climate change vulnerability included four components: climate-related hazard exposure, population density, household vulnerability, and governance.[48] Each component received equal weight in the composite vulnerability calculation. The base model for this study's analysis retained equal weights for each of the four components. The most important reason for this is that without the ability to test the impacts of climate change, there is no way to determine which factors are the most important in determining outcomes. Equal weighting minimizes the impact of personal biases in weighting the vulnerability index baskets, and allows the study to accomplish two important goals. First using the framework of the CCAPS model facilitates cross-model comparison with previous analyses. Second, it maintains a balance between the national data on governance and extractive industries and the sub-national data provided by the climate-related hazard exposure, population density, and household vulnerability components of the CCAPS vulnerability model.

The measures of governance, climate-related hazard exposure, and household vulnerability included in the CCAPS model each incorporate multiple sources of statistical information that have been integrated using Microsoft Excel and ArcGIS software. For example, the physical exposure component includes historical climate hazard data related to cyclones, droughts, floods, and wildfires, as well as identification of low-elevation coastal zones. Historical data have been used instead of future climate predictions due to the variability of predictions for West Africa that emerge from different climate models. However, the low elevation coastal zone information is included as a predictive determinant of where sea level rise may threaten populations in the future.

The UNEP/GRID-Europe database provides information about where climate-related hazards have occurred in the past. The data are stored in rasters, a file type that contains a grid of pixels with values for the event frequency. Rasters are added together in ArcGIS to create a composite score for each pixel on the map. Scores are grouped into five categories, or quintiles, ranging from the places with the highest hazard frequency to the lowest hazard frequency to provide a cross-continent comparison of relative exposure to disasters.

For the household vulnerability and governance components, statistical data regarding various factors were gathered and compiled in an Excel spreadsheet. Each factor was assigned a percent rank among African countries in order to standardize data calculated on vastly different scales. Equal weights were assigned to each factor in order to calculate the component score for each geographic unit on the map. When a household vulnerability statistic was unavailable for a particular country, its absence was balanced by increasing the weight assigned to a statistic measuring a similar characteristic of the country.

For example, if data on adult literacy rates were unavailable, primary school enrollment data received extra weight to compensate for this absence. A similar procedure was followed when governance data could not be found for a particular country. The Excel document was then imported into ArcGIS and joined to a shapefile of Africa, assigning the component scores to the appropriate countries or sub-national regions. After converting the shapefiles to rasters, the four components were added together using a raster calculator that assigned the appropriate weight to each one. For a more detailed explanation of these methods and the selection of each indictor for inclusion in the model, please see the discussion in Busby et al.[49] The specific factors included in the four baskets of vulnerability and their data sources may be found in Table 1. The indicators added to the governance basket for this study appear in red.

Table 1: Composite Vulnerability Components

Component	Weight	Data Source
Climate-Related Hazard Exposure	25%	
Low-Elevation Coastal Zones	4.17%	U.S. Geological Survey (2009)
Cyclone Surge Frequency	4.17%	UNEP/GRID-Europe (1975-2007)
Cyclone Wind Frequency	4.17%	UNEP/GRID-Europe (1975-2007)
Drought Events	4.17%	UNEP/GRID-Europe (1980-2001)
Flood Frequency	4.17%	UNEP/GRID-Europe (per 100 years)
Wildfire Frequency	4.17%	UNEP/GRID-Europe (1997-2008)
Population Density	25%	Center for International Earth Science Information Network (CIESIN) (2000)
Household Vulnerability	25%	
Education	6.5%	
Adult Literacy Rates		*World Development Indicators (2000-2007)*
Primary School Enrollment		*World Development Indicators (2004-2008)*
Health Status	6.5%	
Adjusted Infant Mortality Rate		*CIESIN (1991-2003)*
Life Expectancy at Birth		*World Health Organization (2006)*
Food & Water	6.5%	
Underweight Children		*CIESIN (1991-2003)*
Population w/ Access to Improved Drinking Water		*World Health Organization (2006)*
Healthcare Access	6.5%	
Per Capita Health Expenditure		*World Health Organization (2006)*
Nurse Personnel Density		*World Health Organization (2002-2006)*
Governance	25%	
Globalization	3.57%	KOF Index of Globalization (2009)
Government Stability	3.57%	Polity IV (1999-2008)
Political Variance		
Stable Years		
Government Effectiveness	3.57%	World Bank (2008)
Voice and Accountability	3.57%	World Bank (2008)
Oil and Mineral Dependence	3.57%	U.S. Department of Energy (2005-2008), UN Commission on Trade and Development (2009)
Ethno-Religious Diversity	3.57%	
Ethnic Polarization		*Ethnic Power Relations Dataset (1990-2005)*
Religious Diversity		*Pew Forum on Religion and Public Life (2008-2009)*
Atrocities	3.57%	KEDS (1995-2009)

This study adds three indicators to the governance component of the CCAPS vulnerability model to emphasize governance effects that seem particularly pronounced in West Africa. First, in order to incorporate the various effects on governance associated with oil and mineral extraction, the study created a new variable called "Oil and Mineral Dependence." This variable was calculated for each country using data on exports of commodity groups 3 and 227 (non-ferrous ores and metals and precious stones) from the United Nations Commission on Trade and Development, crude oil export data from the U.S. Department of Energy, and GDP data from the World Bank.[50] In order to use comparable scales for countries across the continent, the study calculated percent ranks for oil and mineral dependency. The percent rank score was then incorporated into the index. Greater oil and mineral dependency—defined as a higher percentage of national GDP earned from oil and mineral exports—is assumed to have a negative impact on the government's accountability to its people and will increase the country's relative vulnerability score (see Appendix A for complete data for oil and mineral dependence throughout Africa and Appendix C for a map of relative oil and mineral dependence).

The procedure for incorporating ethnic and religious dynamics into the governance scores closely paralleled that for the oil and mineral dependence. Much of the literature on the effects of ethnic and religious diversity on governance focuses on the "ELF" statistic, a measure of ethno-linguistic fractionalization determined by the probability that two members of a population, selected at random, will be from different ethnic groups. However, despite cases that show links between ethnic fractionalization and political instability and exclusionary economic policies, African governments also exhibit a degree of power sharing and political bargaining between ethnic groups.[51] Therefore, this study selected the ethnic polarization variable from the Ethnic Power Relations dataset to serve as a proxy for both ethnic fractionalization and the way governments allocate power between ethnic groups. The ethnic polarization variable, in its raw form, is a measure of the percent of the population belonging to politically represented ethnic groups.[52] In Table 2, high scores are considered preferable for governance measures. However, it should be noted that in some cases the scores may be artificially inflated due to post-conflict power sharing arrangements that may or may not represent actual governance outcomes. Also, the scores are based on the subjective opinion of a regional or country expert who must decide what constitutes an ethnic group and what qualifies as political representation. In this case, each country's polarization score was assigned a percent rank among African countries, and the percent rank was incorporated into the index. Equatorial Guinea, Djibouti, and the various island nations in Africa do not have ethnic polarization scores. These gaps were filled by assigning the religious diversity data double weight in the governance vulnerability calculations.

Lastly, this study adds a measure of relative religious heterogeneity into the CCAPS vulnerability model. Using data from a 2009 Pew Forum on Religious and Public Life study, "Mapping the Global Muslim Population," the study tabulates the size of each country's Muslim population. It then calculates the size of the dominant religious group based on these numbers, assuming—as stated in recent research on traditional religions in Africa—that the vast majority of Africans self-identify as Christians or Muslims.[53] A 2009 study of 19 Sub-Saharan African countries by the Pew Forum uses a variety of census, survey, and interview data that includes traditional religious practices in addition to Islam and Christianity. Six countries surveyed had ten percent or more of the population that identified their religious practices as corresponding to traditional religions.[54] However, none of these countries would change more than one quintile from their religious diversity categorization under this study's original methodology. At the composite governance level, this effect becomes further diffused, indicating that while traditional religions should not be ignored, their exclusion from this dataset does not skew the results in a significant way. Percent ranks of these values were calculated and added to this study's governance index, with relatively homogenous populations assumed to provoke less vulnerability than religiously heterogeneous populations. The scores are calculated at the national level, due to the unavailability of geo-

referenced data at the sub-national level. In the final composite, the religious heterogeneity and ethnic polarization scores are averaged together as a single factor of the governance basket.

Table 2 illustrates the variation between information captured by religious diversity and ethnic polarization. Burkina Faso, Guinea, Guinea-Bissau, Nigeria, Sierra Leone, and Togo stand out as countries with ethnic polarization and religious diversity scores that are divided by more than 0.3 (see Appendix B for continent-wide data and Appendices D and E for maps of Ethnic Polarization and Religious Diversity scores).

Table 2: Ethnic Polarization and Religious Diversity by Country

Country	Ethnic Polarization Score	% Rank for Ethnic Power Relations	Religious Majority as % of Total Population	% Rank for Religion
Benin	0.741	0.377	75.6	0.211
Burkina Faso	1	0.866	59.0	0.057
Central African Republic	0.765	0.466	91.1	0.423
Côte d'Ivoire	0.731	0.355	63.3	0.076
Cameroon	0.609	0.177	82.1	0.250
Republic of the Congo	0.771	0.511	98.6	0.711
Gabon	0.782	0.533	90.5	0.403
Ghana	0.700	0.311	84.1	0.288
Guinea	0.864	0.711	84.4	0.307
Gambia	0.752	0.444	95.0	0.500
Guinea-Bissau	0.828	0.644	57.8	0.038
Equatorial Guinea	.	.	96.0	0.519
Liberia	0.817	0.622	87.8	0.346
Nigeria	0.713	0.333	50.4	0.000
Senegal	0.752	0.422	96.0	0.519
Sierra Leone	0.859	0.688	71.3	0.153
Togo	0.937	0.755	87.8	0.346

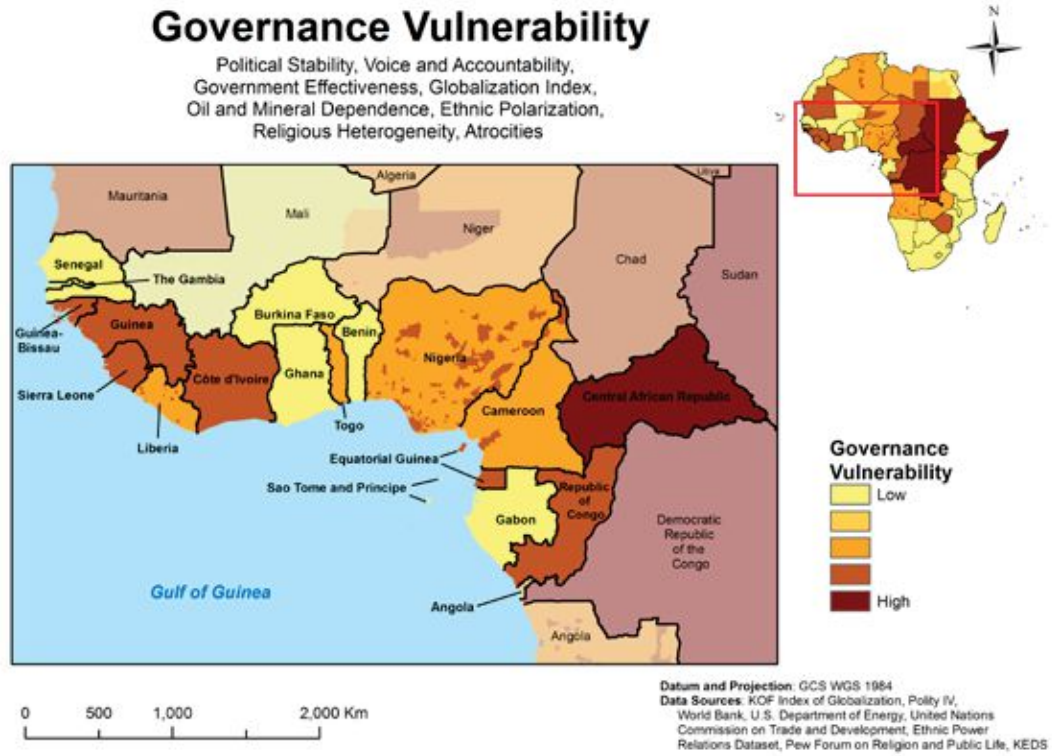
In addition to the incorporation of oil and mineral dependence and ethno-religious diversity data, this study provided geo-referenced information corresponding to these characteristics. Data from the U.S. Geological Survey displays oil and mineral extraction sites, and the Geocoded Ethnic Power Relations (GeoEPR) dataset contains the locations of ethnic groups at the sub-national level, as well as their access to political power.[55] Maps analyzed in later sections of this paper will place oil and mineral extraction sites and marginalized ethnic group populations in relation to various components of the CCAPS vulnerability model—climate-related hazard exposure, population density, household exposure, and governance—to provide a more detailed understanding of the local vulnerabilities specific to these sites.

PART 4: FINDINGS

Governance Vulnerability Scores

The addition of oil and mineral dependence, ethnic polarization, and religious diversity in the governance component of CCAPS vulnerability model generated results that fit closely with many of the team's hypotheses about the role of these components in governance. For example, at the continent-wide level, the addition of ethnic and religious diversity causes Sudan and the Democratic Republic of the Congo to be relatively more vulnerable than in previous calculations with the CCAPS model. The reduction of the weight placed on violent events also causes a more uniform distribution of vulnerability that smoothes over some sub-national variability in Côte d'Ivoire, Libya, Sudan, and Somalia as well (see Figure 5).

Figure 5



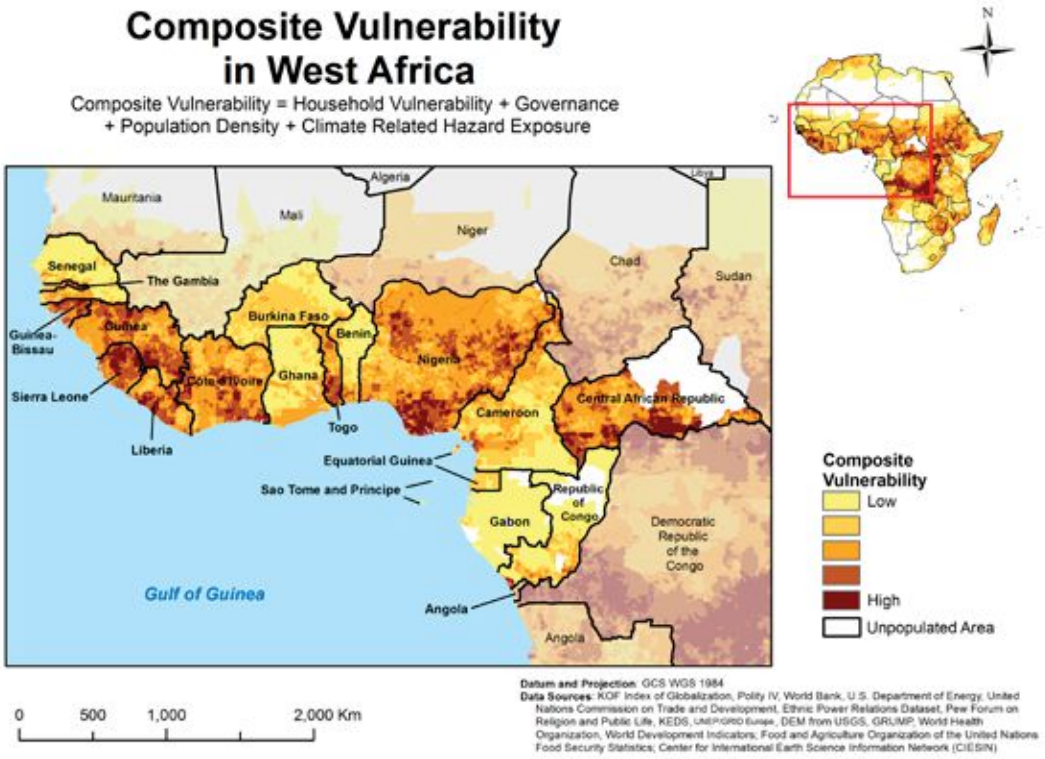
In West Africa specifically, the results indicate that the Central African Republic, a state with both ethnic diversity and mineral endowments, faces more governance vulnerability than any other country in the region. Analysis of the indicators included in governance vulnerability indicates that low levels of openness to globalization, poor government effectiveness, and political instability drive this classification as most vulnerable. Meanwhile, the Republic of the Congo, Sierra Leone, Guinea, Guinea-Bissau, Côte d'Ivoire, and Equatorial Guinea fall in the fourth most-vulnerable quintile. In general, the countries in this group have received low scores for government effectiveness and voice and accountability that contribute to their vulnerability. However, the Republic of the Congo and Equatorial Guinea also score poorly due to high levels of oil dependence; whereas, Sierra Leone, Guinea, and Guinea-Bissau have religiously diverse populations. Interestingly, Liberia's governance scores stand out due to their contrast with its neighbor, Sierra Leone, with whom Liberia shares a history of recent conflict. The difference between the two countries is driven largely

by Sierra Leone's greater religious diversity and lower ethnic polarization scores, indicating a less inclusive political process than in Liberia. Finally, according to the chart of religious distributions found above, one would expect slightly more uniform scores for governance across the region's coastline. This seems to demonstrate that the religious diversity data were offset by oil and mineral dependence, ethnic polarization, and other data included in the model.

Composite Vulnerability: West African Model

The composite vulnerability calculations that include all four components—climate-related hazard exposure, population density, household vulnerability, and governance—add both important considerations for measuring climate change impacts and valuable sub-national data for appropriate targeting of climate change adaptation measures. The countries with the most vulnerability in the West African model include Sierra Leone and its border with Guinea, the southern and northern peripheries of the Democratic Republic of the Congo, western Ethiopia, southern Sudan, southern Chad, Guinea-Bissau, and the Niger Delta (see Figure 6). It is difficult to generalize about the drivers of this vulnerability across these widely varying countries; however, they each score poorly across all of the component baskets.

Figure 6



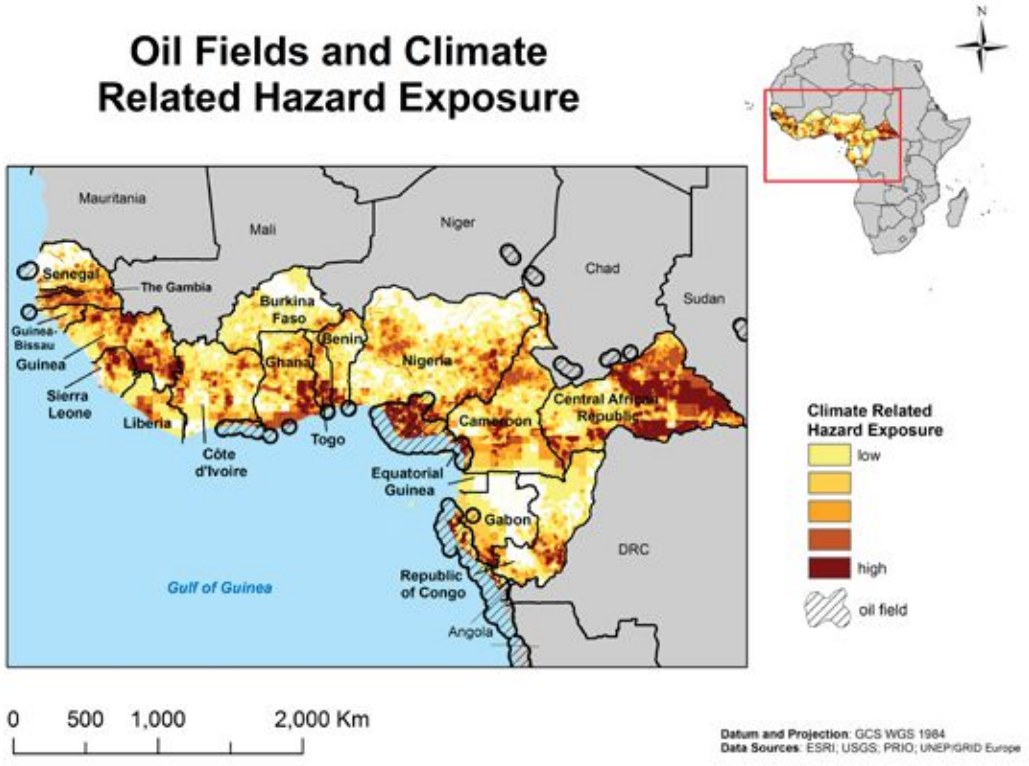
Locating Oil and Mineral Extraction Sites

Figure 7 shows selected oil fields in West Africa, along with the region's physical exposure to climate-related hazards. Analysis of the geographic overlap between hazard exposure and oil field identifies regions with high climate hazard exposure that simultaneously confront varied degrees of environmental degradation drilling for oil. Overlaying these sites on top of climate-related hazard exposure, rather than including the sites in the vulnerability index, helps to take into account that governments manage risk in different ways.

For example, in the Niger Delta oil extraction has caused marked air and water contamination due to the estimated 2,300 cubic meters of oil that are spilled into the Delta annually.[56] The short and long-term effects of these spills place the population at increased household vulnerability due to their already reduced quality of life. Meanwhile, the potential for sea level rise and flooding to occur at the mouth of the Niger River could mean that contaminated waters will spread even farther in the region. Further west along the coast, the gold industry in Ghana has been linked to mercury and cyanide contamination of rivers, drinking water supplies, and fish.[57] The concentration of gold mines has thereby created an increased vulnerability for the communities that live in the region—an effect that may not be captured in the primarily national-level data in the household vulnerability index.

In addition to considerations of environmental impacts of extractive activities, understanding where oil wells and mines are located may help American policymakers to consider the economic implications of climate change for the U.S. Approximately 13.5 percent of U.S. crude imports lie in the Gulf of Guinea, with a particular concentration in the area beginning around the Niger Delta and following the coast south to Angola.[58] In Figure 7, we see oil facilities exposed to disasters, particularly in Nigeria and Gabon. While flooding is not a major concern for land wells in the long term, sudden-onset extreme weather events still have the potential to disrupt distribution and transport, the so-called "midstream" of the oil sector. In this sense, the exposure of African oil fields to climate-related hazards may have implications for the U.S. economy, in addition to local impacts on these sites.

Figure 7

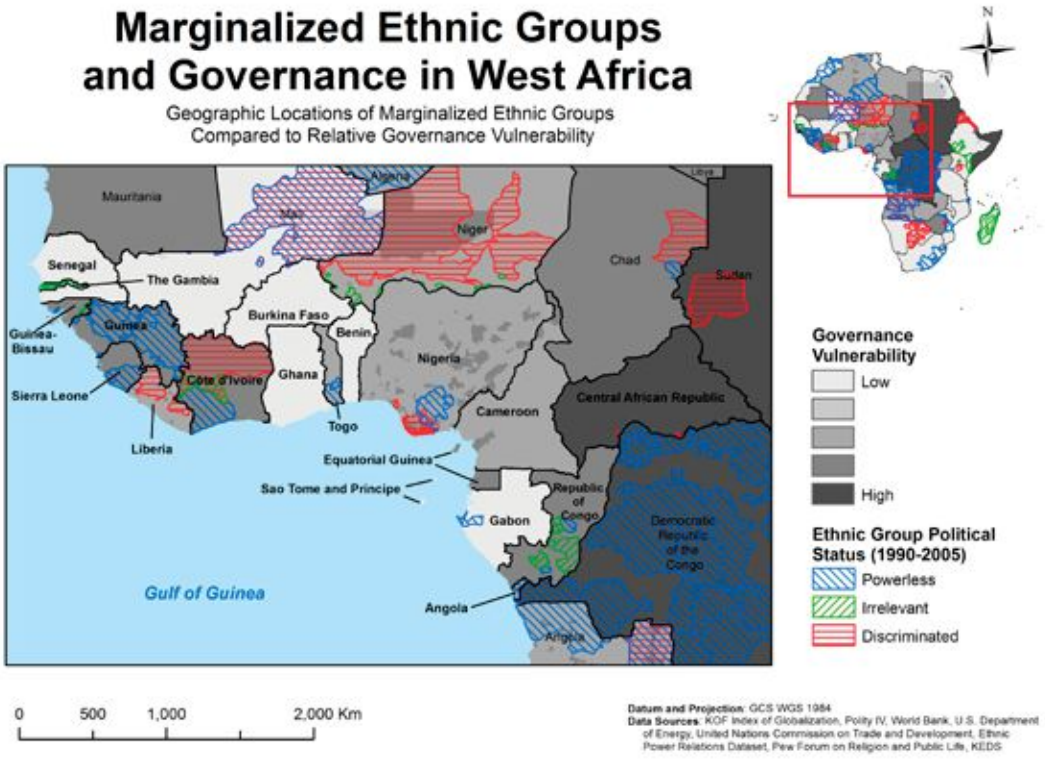


Locating Marginalized Ethnic Groups

In order to analyze how the geographic locations of marginalized ethnic groups interacted with the various components of our vulnerability index, this study used data from the GeoEPR dataset to create overlays of groups classified as powerless, irrelevant, or discriminated during the period 1990 to 2005.[59] These overlays were then mapped on top of population density, governance, violent events, and climate-related hazard exposure rasters. The classification of various ethnic groups as powerless, irrelevant, or discriminated is a subjective one: teams of regional experts were asked by researchers to classify groups according to their political status. Groups classified as marginalized do not capture the full range of ethnic diversity or the effects of ethnic diversity on governance. However, it does seem highly probable that groups without even minimal political representation or actively discriminated against may be left out of the government's resource allocation decisions. In the face of climate change, this may translate into exclusion from disaster aid distribution or adaptation strategies. Additionally, marginalized ethnic groups may experience decreased access to healthcare, education, and food security that cannot be fully described by national-level statistics on household vulnerability. Therefore, understanding where marginalized ethnic groups live may help policymakers and aid workers to target these populations appropriately.

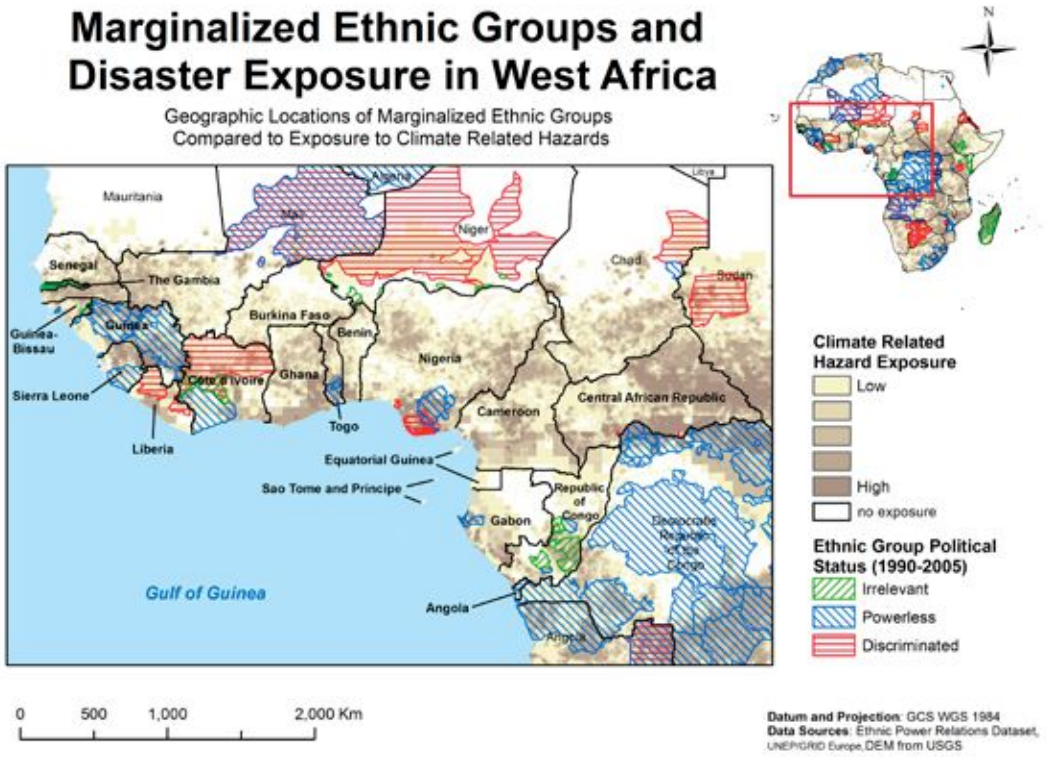
With the exception of the Democratic Republic of the Congo, Republic of the Congo, and Sierra Leone, the presence of these three types of marginalized ethnic groups did not correspond to the countries whose governance scores fell in the most vulnerable quintile (see Figure 8). In fact, it would be extremely difficult to generalize about a country's governance capacity based on the presence of marginalized ethnic groups. However, this could be due to the subjective definition of which groups are marginalized and the fact that marginalization does not necessarily indicate that a country is particularly heterogeneous or exclusionary in its ethnic relations. A similar observation may be made of maps that include the marginalized ethnic group overlay and data about violent events and population density: the presence of a marginalized group does not closely match extremes of population density or violent event history (see Appendices I and J).

Figure 8



The geographic coincidence of climate hazard exposure with marginalized ethnic groups in West Africa seems relatively more problematic based on this basic mapping exercise (see Figure 9). For example, the presence of discriminated and powerless ethnic groups in the Niger Delta could be particularly problematic in the event of sea level rise or another disaster in this densely populated coastal zone. Also, various powerless and discriminated ethnic groups are located in Guinea, Sierra Leone, and Liberia in regions that face a patchy incidence of high exposure to climate-related hazards. Reducing climate security vulnerability in these areas will thus require the governments of these countries to target the territories of these groups, despite political pressure to focus all energies on other constituencies.

Figure 9



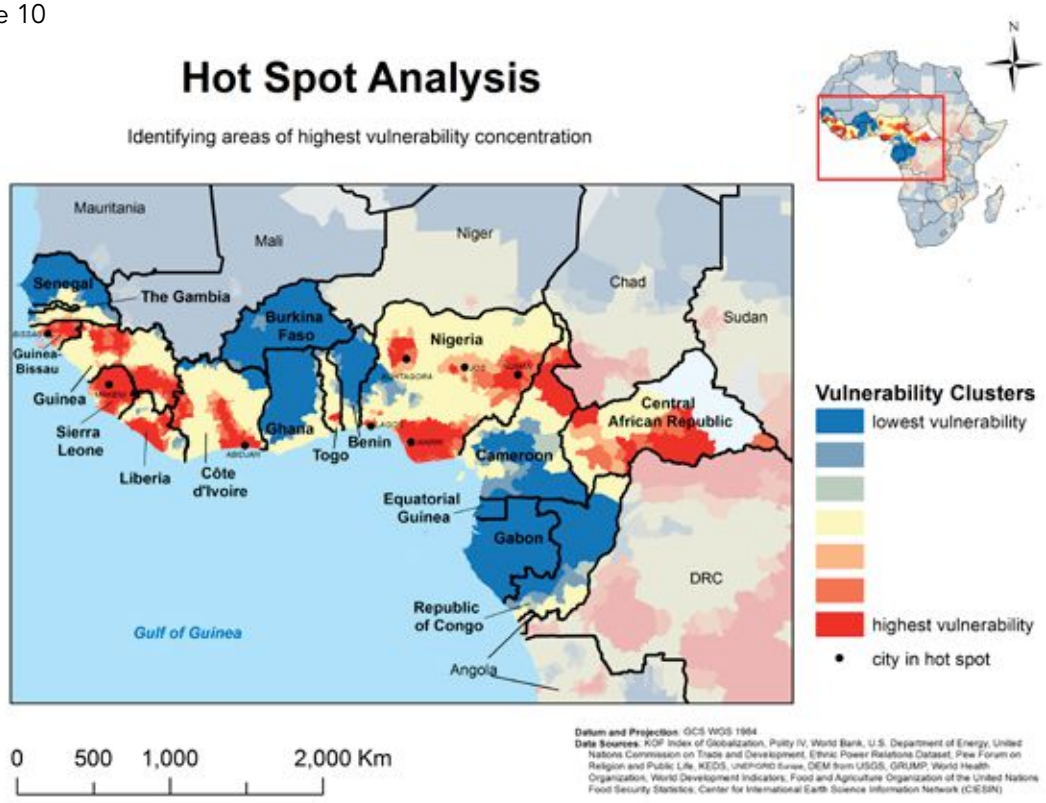
Cluster Analysis

Cluster analysis is used to determine areas of high concentration of a variable of interest. Its most common uses are in criminology or epidemiology. For example, local police may want to know in which neighborhoods more muggings take place as compared to a city average. In turn, they could use this information to place scarce security cameras at areas identified as "clusters" of mugging frequency. They may also be curious about why muggings tend to concentrate around a certain area. Examinations of neighborhood characteristics can shed light on the causes of these spatial patterns.

Since the primary goal of this analysis is to guide hypothesis development and future data collection, this study applied cluster analysis to examine the spatial patterns underlying the Africa vulnerability data. By examining the areas of highest vulnerability concentration through case studies, the study examines the causal mechanisms behind climate change vulnerability. To implement the cluster analysis, the study first breaks down the composite maps to the cell level. The cell values are associated with the smallest available administrative unit. The aggregate of

these cell values is the vulnerability score for the administrative unit. The study then compares the vulnerability values of each administrative unit to those around it in a "neighborhood" of selected size. A score of concentration is calculated for each unit, with a higher score signifying that there are many high values surrounding the unit. The scores are then standardized into Z-scores. The highest scores are interpreted as the areas with the strongest signal of spatial patterns in vulnerability (see Figure 10).

Figure 10



PART 5: CASE STUDY ANALYSIS: NIGERIA AND GUINEA-BISSAU

Nigeria: Ethnic Violence, Resource Conflict, and Vulnerability

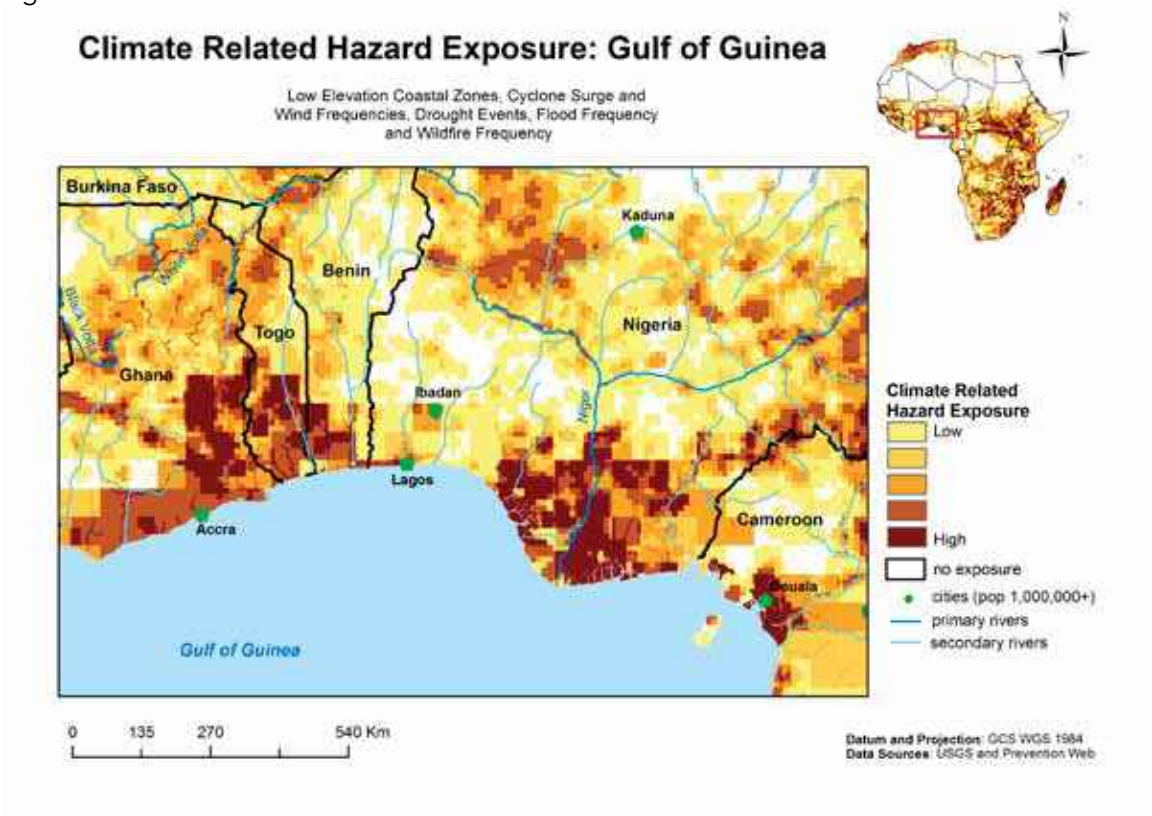
Calculations of composite vulnerability show Nigeria to be highly vulnerable to climate change in two primary locations: northern Nigeria and the Niger Delta. The individual component calculations explain why these areas appear to be highly vulnerable. The Niger Delta is a low-elevation coastal zone that has historically experienced violence stemming from ethnic diversity and oil wealth. At the household vulnerability level, sub-national calculations showed the stark contrast and inequality between southern Nigeria and northern Nigeria, which has a high concentration of poverty, illiteracy, and poor access to healthcare. In addition to the highly vulnerable regions of the Niger Delta and northern Nigeria, Jos and Lagos both stand out as population centers that face unique vulnerability. Jos stands at the center of the Christian-Muslim divide in Nigeria and

regularly experiences outbreaks of violence. Lagos is a megacity with a large poor population and is located in a low-elevation coastal zone. The two new national-level variables added in this model—oil and mineral dependence and ethno-religious diversity—magnified Nigeria's vulnerability to climate-related hazards and household-level stressors because of its deep social divisions between Christians and Muslims and its economic dependence on oil exports. The coalescence of these characteristics justifies a closer look at Nigeria.

Nigeria's physical exposure to climate-related hazards concentrates in the Niger Delta and the region around the city of Lagos, due to their high potential for flooding (see Figure 11). The Niger Delta is vulnerable to flooding because of the region's lowlands and dissection by numerous waterways. Sea level could rise up to one meter by 2100, which would consume 18,000 square kilometers of land in the Delta. This represents a loss of 2 percent of Nigeria's land in one of its most densely populated regions.[60] If this were to happen, 80 percent of the population could be displaced by the floods.[61]

Another issue of importance is the potential economic effect of sea level rise on the population and the nation. Sea level rise would increase erosion, change soil composition, and decrease agricultural yields in the region. Also, the intrusion of seawater into the fresh water deposits will negatively affect fisheries by destroying spawning grounds and changing the ecosystems where fish thrive.[62] In addition, flooding could further spread waters contaminated with oil into new areas of the Delta, further affecting the population's access to water and the fragile ecosystem that currently supports fishing and agriculture. Of national interest, sea level rise could affect the oil sites in the Delta. The oil from the Delta supplies 95 percent of Nigeria's export revenue and 40 percent of the government's budget.[63] Flooding in the Delta could place stress on existing oil infrastructure and potentially even disrupt oil transport to the coast and cause interruptions in export sales.

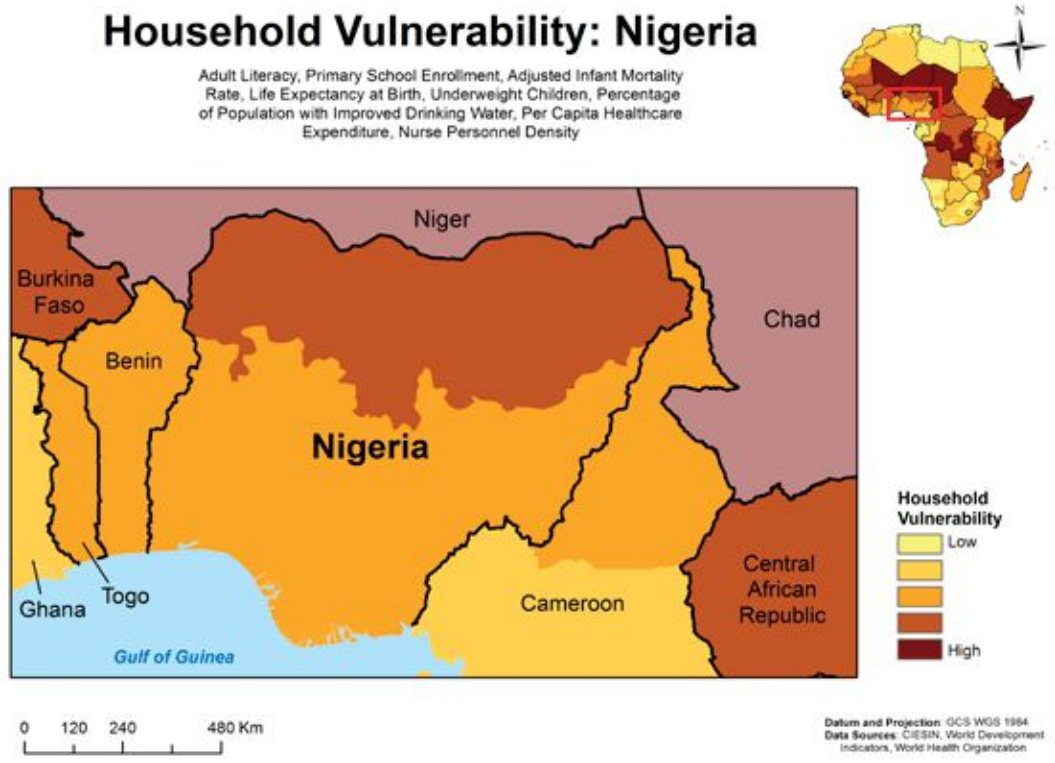
Figure 11



Northern Nigeria has greater household vulnerability than the rest of Nigeria because it is the least developed region in the country. At the root of this regional disparity lies uneven educational attainment. The northern region of the country contains the only states with literacy rates below the national average at 66 percent; all but one of the highest-ranked 15 states for basic literacy—defined as 75 percent to 91 percent attainment—is located in the south.[64] In spite of the fact that Nigeria's population is concentrated in the north, 80 percent of the nation's university students originated in the south, and 75 percent of the technocracy within the national bureaucracy are also southerners. These educational disparities have manifested themselves in inequitable development, with southern Nigeria being more developed than northern Nigeria. Average incomes in southern states are nearly double the average incomes in the northern states, and southern populations have greater access to mobile phones, television, and the internet (see Appendix K for additional information on these inequalities).[65]

In our household vulnerability calculations, the disparities in development manifest themselves in health statistics: infant mortality rates and the incidence of underweight children are highest in northern Nigeria (see Figure 12). The overall inequality of development makes northern Nigeria less able to adapt to drought and desertification. Northern Nigeria is losing 350,000 hectares every year to desertification, and the spreading desert affects 50 to 75 percent of the land in 10 northern states.[66] This is a semi-arid region that straddles the drier Sahel, and many of the people in this region are dependent on the land for their livelihood. The spreading desert affects roughly 35 million people in northern Nigeria and the region's population faces many household level challenges to adapt to their changing circumstances.

Figure 12



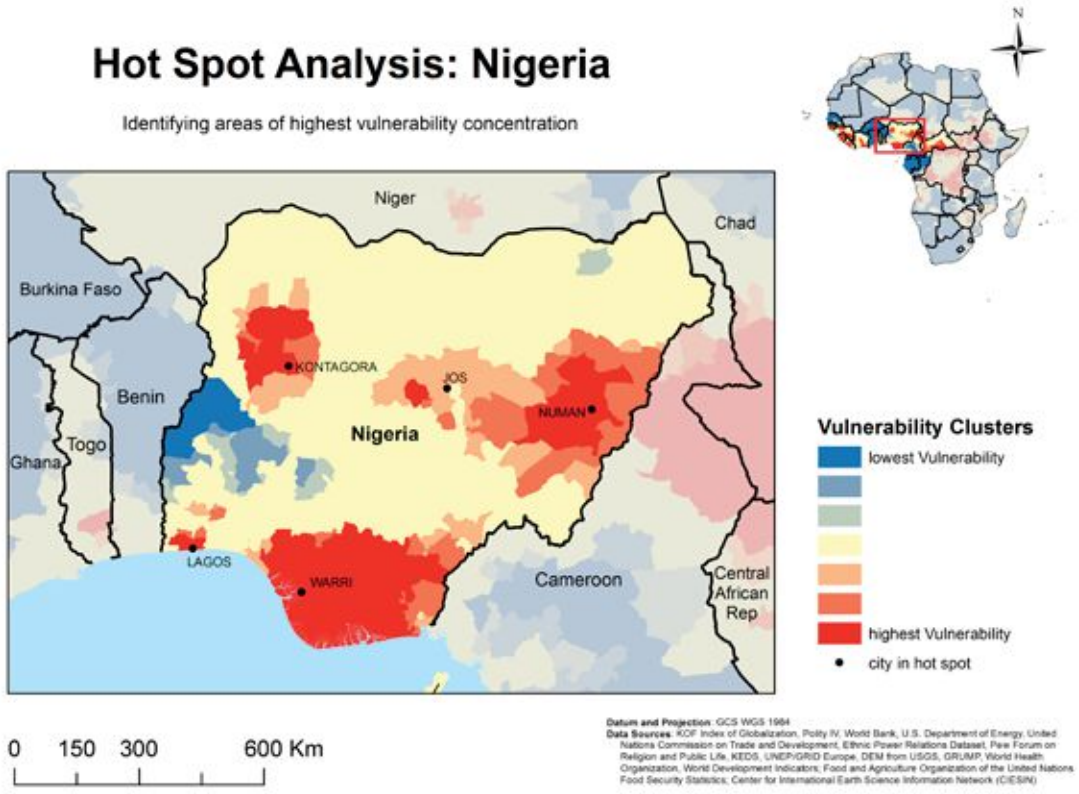
Nigeria is one of the most religiously diverse countries in Africa, and this dynamic has historically shaped Nigerian politics and conflicts. Nigeria is divided roughly evenly between Christians (48.5 percent) and Muslims (50.5 percent), with Muslims concentrated in the north, and Christians concentrated in the south. Islam has spread from North Africa into West Africa and has existed in Nigeria for 1,000 years among the savanna and Sahel populations. Meanwhile, Christianity has been practiced for 500 years among the coastal populations in the south who had contact with Europeans. The religion later spread throughout southern Nigeria when the British colonized the country in the 20th century. Today, Sharia Law has been implemented in 12 states in northern Nigeria, causing riots in a number of states (see Figure 13).[67] In the northern city of Jos in 2001, Muslims and Christians clashed over the appointment of a Muslim to the state government, resulting in over 1,000 deaths. Similar clashes in Jos led to 700 deaths in 2004, 300 deaths in 2008, and 1,000 deaths in January and March 2010.[68] Jos is a city on the border of the Muslim-Christian divide, and the city has been the epicenter for widespread religious tensions in the country. These tensions affect the governance in the country because Muslims and Christians must share power, and government leaders are careful not to upset these tensions when making policy decisions. In the event of a slow or rapid-onset climate event, policymakers will contend with the pressures of responding to the hostilities of their constituencies when distributing aid or resources for economic recovery.

Figure 13

Nigeria's economy relies heavily on oil exports for foreign exchange and government revenue. Oil makes up 95 percent of Nigeria's export revenue and 40 percent of the government's revenue.[69] Nigeria has the 10th largest proven oil reserves in the world and is the 15th largest oil exporter. Nigeria is the largest oil exporter in Africa. Industry provides employment for only 6 percent of the Nigerian workforce, but it comprises 40 percent of GDP due in large part to the oil sector. The focus on oil exports has diverted investments from other sectors, and poverty in Nigeria has expanded from 28 percent of the population in 1980 to 66 percent in 1996 and 70 percent in 2007.[70] Furthermore, the rebel groups in the Delta region, which produces 91 percent of Nigeria's oil, frequently protest the pollution and lack of investment in their communities. The Ogoni writer Ken Saro-Wiwa was famously hanged by the Nigerian government in 1995 after leading a protest movement against the oil pollution of the agricultural lands of his Delta ethnic group.[71] In 2006, the World Wide Fund for Nature called the Niger Delta one of the most polluted places on earth because of the roughly 7,000 oil spills that have occurred since 1970.[72] Nigeria's anti-corruption chief, Nuhu Ribadu, estimated in 2004 that 40 percent of Nigeria's oil wealth is lost to corruption and mismanagement.[73] Ironically, Nigeria imports most of its fuel due to poor infrastructure within the country.[74] The richness of Nigerian oil reserves, rather than providing capital for development, has more often than not served as the spoils of political power, fueling conflict, and contributing to environmental degradation and household vulnerability.

The cluster analysis discussed earlier in this paper used this study's estimations of climate-related hazard exposure, population density, household vulnerability, and governance to calculate concentrations of composite vulnerability (see Figure 14). A closer look at the results reveals a number of areas in Nigeria where vulnerability and violence are concentrated. Two of these areas were previously mentioned: Jos and the Niger Delta. Jos is a city where some of Nigeria's worst sectarian violence has occurred, in addition to facing high vulnerability to climate change. The Niger Delta also shows up as a hotspot because of its vulnerability to climate-related hazards, and it is also the historical home of rebel movements for southern Nigeria. Likewise, the Niger Delta city of Warri faces high vulnerability to climate change, as well as a history of violent ethnic clashes over control of the oil-rich city. Ethnic fighting between the majority Ijaw and the dominant Itsekiris since the 1990s has led to hundreds of deaths and the disruption of oil production.[75] Finally, Lagos also faces high vulnerability to climate change. Lagos is the largest city in Nigeria with a total population of more than 15 million people and population densities reaching 20,000 people per square kilometer in some parts of the city.[76] Two-thirds of all Lagos residents live in a slum, and Lagos currently has at least 42 slum areas.[77] This means that roughly 10 million people in Lagos live in slums with high concentrations of poverty and little to no access to proper sanitation, electricity, or clean water.[78] The city's low elevation threatens to make Lagos the site of widespread flooding and displacement due to sea level rise—circumstances the population will be ill-equipped to face without substantial government assistance.[79]

Figure 14

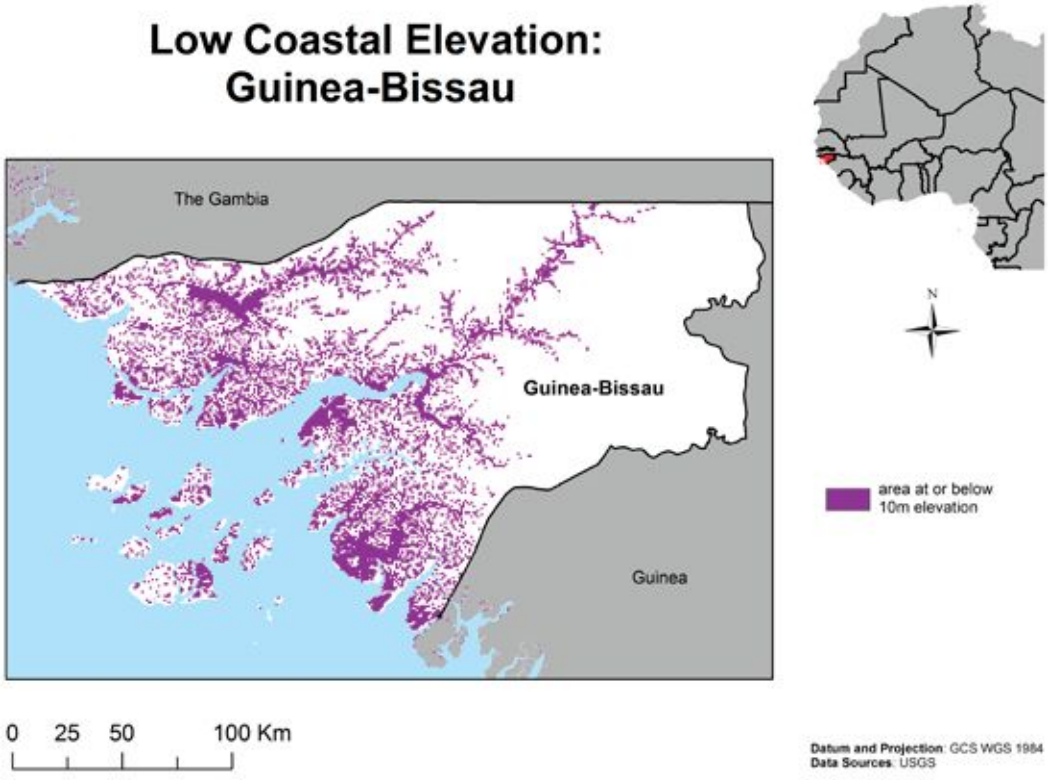


Nigeria contains some of West Africa's most vulnerable locations, which will likely require intensive government initiative to adapt these locations to the potential effects of climate change. Flooding and sea level rise along the coast are natural occurrences that may become worse as time passes. The lack of development in northern Nigeria makes this region particularly vulnerable to climate-related hazards since the populations in the region do not have as many resources to prepare for a possible increase in droughts. Meanwhile, the religious and ethnic dimensions of the population complicate Nigeria's political economy and may prevent the adequate allocation of resources to all sectors of the population. Nigeria's substantial oil wealth could reduce the imperative to meet public needs and provide an incentive for government focus on maintaining control of the resources instead.

Guinea Bissau: Poverty, Subsistence Agriculture, and Vulnerability

Guinea-Bissau consistently ranked among the most vulnerable countries in West Africa according to this study's model. It illustrates the potential impacts of climate change on populations with low adaptive capacity at the national and community level, because the government and its people alike lack sufficient resources to address climate change. The primary drivers of Guinea-Bissau's climate vulnerability are physical exposure, dependence on agriculture and fishing, ethnic polarization, and poor governance. Low-elevation coastal zones stand out as Guinea-Bissau's clearest indicator of physical vulnerability. Most of Guinea-Bissau's terrain consists of coastal swamps and mangroves, and over 19 percent of its land area lies in areas less than 10 meters above sea level.[80] Increased flooding and saltwater intrusion due to global sea level rise could potentially affect these areas. The population would feel the losses quickly, as they rely on mangrove stands for rice cultivation. Like many of its West African neighbors, Guinea-Bissau faces rainy seasons and long dry seasons, with abrupt transitions. The West African monsoon that characterizes the region's climate is less stable than its eastern counterpart, and long droughts such as those that affected the area during the 1970s and 1980s are possible.[81] Northern Guinea-Bissau borders the Sahel region, and anecdotal evidence suggests that the long droughts that characterize the Sahel may be spreading to this region.[82]

Figure 15



The livelihoods of Bissau Guineans are vulnerable to climate change. Even by African standards, little industry exists in Guinea-Bissau. Most of the population (about 82 percent) work as subsistence farmers.[83] Climate change has already begun to affect coastal farmers through saltwater encroachment into their rice paddies.[84] Some ethnic groups, such as the Diola in the north, the Fula, and the Mandinga, say that the weather variation is abnormal and blame anthropogenic climate change.[85] Disruption of traditional ways of life has also led to more substantive problems. In particular, farmers who can no longer grow rice have shifted into cashew production.[86] This can lead to a crippling dependence on a single crop for entire communities, putting their livelihoods and even their ability to feed themselves at the mercy of the harvest and of international cashew prices. Substituting cash crops for subsistence crops may boost incomes but increases food insecurity and makes populations more vulnerable to price fluctuations.[87]

Climate change is predicted to have adverse effects on fisheries and fishing. Rising sea temperatures and changes in the oceans' other dynamics, such as acidification and loss of nursery areas, are predicted to reduce fish populations. Meanwhile, in places with rich fisheries like Guinea-Bissau, the destruction of coral reefs and mangroves destroys fish spawning grounds, decreasing the availability of fish, limiting the livelihoods of fishermen, and leading to precarious food security.[88] In addition, fisheries play a vital role for Guinea-Bissau's government, with fees for fishing licenses providing 35 percent of government revenue.[89] Declining fish populations have even pushed some fishermen into illicit activity, such as human trafficking or the illegal drug trade that has begun to grow in the poorly regulated space of Guinea-Bissau.[90]

Guinea-Bissau scored the lowest in this study's sample in terms of governance and adaptive capacity. This poor performance is due to ethnic conflict and the continued struggle for power between the government and the military, which often occurs over ethnic lines. Guinea-Bissau is a striking example of a present-day national boundary that—while it has some trappings of a state such as a flag and membership in the UN—has never really benefited from a functional government.

The former colonial power, Portugal, dominated the region from the 1500s until independence in 1974; however, it made few investments in infrastructure or institutions.[91] After independence, the new country faced formidable challenges to establishing an effective government: ethnic, personal, and factional rivalries have led to eight coups or coup attempts in 36 years of independence. The assassination of Amlicar Cabral, founder of the revolutionary African Party for the Independence of Guinea and Cape Verde (PAIGC), shortly before independence left the PAIGC without a strong leader. As a consequence, Guinea-Bissau did not experience the period of stability seen in Senegal under Leopold Sedar Senghor or Guinea under Ahmed Sekou Toure, which allowed these countries to build institutions.[92] Within six years of independence, a military government under revolutionary veteran Joao Bernardo Vieira took power in a coup. Rivalries between civilian leaders and the military, fueled by ethnic tensions, became a dominant feature of Bissau Guinean politics. This trend has continued to the present day: in March 2009, longtime Vieira rival Batista Tagme Na Waie died in a mysterious bomb blast. In response, Vieira was killed in a machete attack a week later by army troops loyal to Waie, who were also of Waie's ethnicity.[93]

The government's inability to collect revenue and pay soldiers due to this instability in turn creates more instability and social problems. In April 2010, the U.S. labeled two high-level members of the military "drug kingpins" under the Drug Kingpin Act.[94] The arrest of Prime Minister Carlos Gomes Junior the same month by soldiers showed that the ethnic and political divisions that have caused conflict since independence still remain.[95]

Climate change could cause a humanitarian disaster in Guinea-Bissau, with flooding displacing people and damaging infrastructure, and the government lacking resources to respond effectively. Over a longer period, climate-related degradation of Guinea-Bissau's agricultural economic base could heighten the country's aid dependence and drive more Bissau Guineans to work in illicit occupations due to lack of opportunity in the legitimate economy. Falling revenues from agriculture and the fishing industry would further diminish government adaptive capacity, while the concentration of production in a few crops at the expense of subsistence methods will diminish household adaptive capacity. At the same time, continued ethnic infighting and decreasing government revenues will leave the government unable to address the needs of its population. Consequences of unchecked climate change in the region could include food insecurity, humanitarian disasters, regional instability, and greater contribution to transnational threats.

PART 6: CONCLUSION AND SUGGESTIONS FOR FURTHER RESEARCH

The analysis presented in this paper highlights the importance of ethnic polarization, religious diversity, and extractive industries as measurements of governance vulnerability in West Africa. Ethnic and religious diversity can decrease government willingness to invest in public goods like adaptation to climate change, increase the likelihood of conflict, and may cause some ethnic groups to be inequitably excluded from disaster aid and recovery and policies designed to help the population to adapt to a changing climate. Meanwhile, a country's reliance on extractive industries can reduce the government's accountability and responsiveness to the public. Both of these effects increase governance vulnerability. As communities in such countries are exposed to the likely effects of climate change—floods, droughts, and extreme weather events—governments may be less likely to respond or adapt to these events.

Governments that are dependent on extractive industries should act to diversify their economies. Governments in West Africa that exploit energy or mineral resources at the expense of agriculture, manufacturing, and services face high vulnerability to economic shocks. Minerals, oil, and natural gas prices are determined by the global market, and economies dependent on these resources will eventually experience heavy losses as prices fluctuate between highs and lows. Economic shocks in already poor and underdeveloped countries increase the likelihood of instability and conflict, especially in ethnically diverse societies. A more diversified economy will also reduce the "rentier effect" by creating additional sources for government revenue, thereby increasing the government's responsiveness to the population and increasing its willingness to invest in the adaptive measures its population needs to withstand the effects of climate change.

Governments should also act to decrease inequality in ethnically and religiously divided communities. The ethnic groups within West Africa have, for the most part, peacefully coexisted for decades or centuries. The roots of many of the conflicts can be traced to real or perceived inequalities between ethnic or religious groups. Certain ethnic groups may benefit from political patronage and receive better jobs, access to schools, more health facilities, or preferential investment in climate change adaptation. This may increase tensions with neighboring groups, especially if both groups live in the same vicinity, and the marginalized group is larger or indigenous to the region. These dynamics could increase the likelihood of conflict, and conflict reduces investment, hampers local economies, and fosters deeper mistrust between groups. Therefore, governments must play an active role in mitigating stark inequalities between ethnic and religious groups and ensuring that these inequalities do not increase as the effects of climate change are felt in the region.

APPENDICES

Appendix A. Oil and Mineral Dependence

Country	Oil/Minerals Intensity	Oil Intensity	Minerals Intensity	GDP (1,000,000 USD)
Republic of Congo	0.98	0.71	0.27	7765
Equatorial Guinea	0.95	0.95	0.00	10040
Angola	0.78	0.77	0.02	51072
Libya	0.62	0.62	0.00	60948
Gabon	0.55	0.53	0.02	10927
Chad	0.51	0.51	0.00	7225
Mauritania	0.42	0.13	0.29	2611
Algeria	0.40	0.40	0.00	129919
Botswana	0.40	0.00	0.40	10216
Nigeria	0.37	0.37	0.00	163432
Zambia	0.27	0.00	0.27	11080
Namibia	0.26	0.00	0.26	6936
Mozambique	0.25	0.07	0.18	7632
Zimbabwe	0.24	0.00	0.24	2161
Guinea	0.22	0.00	0.22	3769
Sudan	0.17	0.17	0.00	50305
Mali	0.16	0.00	0.16	6680
Côte d'Ivoire	0.12	0.11	0.01	9065
Cameroon	0.11	0.10	0.01	19601
Ghana	0.11	0.00	0.11	13705
Sierra Leone	0.10	0.00	0.10	1838
Lesotho	0.07	0.00	0.07	1517
South Africa	0.07	0.00	0.07	264570
Burundi	0.07	0.00	0.07	989
Niger	0.07	0.00	0.07	3974
Central African Republic	0.06	0.00	0.06	1639
Tunisia	0.06	0.05	0.01	33832

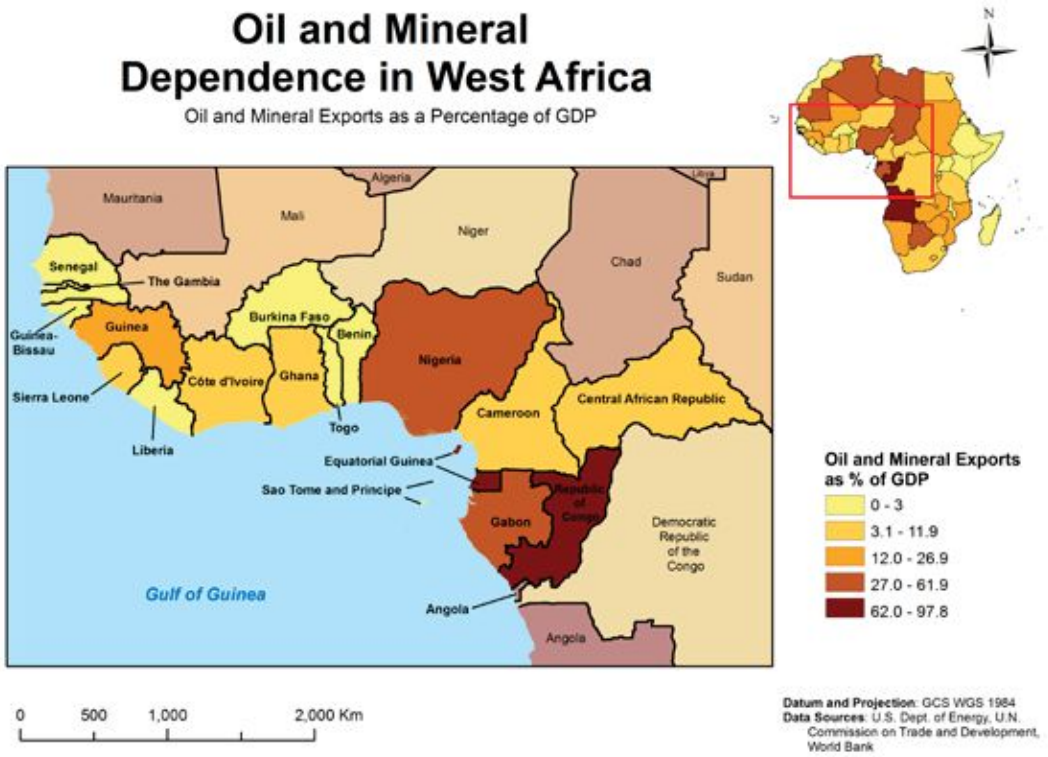
Country	Oil/Minerals Intensity	Oil Intensity	Minerals Intensity	GDP (1,000,000 USD)
Tanzania	0.05	0.00	0.05	14801
Democratic Republic of Congo	0.05	0.02	0.03	20022
Egypt	0.05	0.04	0.01	127742
Morocco	0.03	0.00	0.03	70572
Somalia	0.03	0.00	0.03	2508
Rwanda	0.03	0.00	0.03	3286
Togo	0.02	0.00	0.02	2434
Mauritius	0.01	0.00	0.01	7331
Uganda	0.01	0.00	0.01	11429
Madagascar	0.01	0.00	0.01	6827
Senegal	0.01	0.00	0.01	10633
Liberia	0.01	0.00	0.01	681
Kenya	0.00	0.00	0.00	26193
Djibouti	0.00	0.00	0.00	818
Ethiopia	0.00	0.00	0.00	15611
Swaziland	0.00	0.00	0.00	2745
Benin	0.00	0.00	0.00	5336
Burkina Faso	0.00	0.00	0.00	6799
Gambia, The	0.00	0.00	0.00	597
Seychelles	0.00	0.00	0.00	715
Eritrea	0.00	0.00	0.00	1275
Guinea-Bissau	0.00	0.00	0.00	348
Malawi	0.00	0.00	0.00	3424
Cape Verde	0.00	0.00	0.00	1327
Comoros	0.00	0.00	0.00	447
Sao Tome and Principe	0.00	0.00	0.00	138

Appendix B. Ethnic Polarization and Religious Diversity

Country	Ethnic Polarization Score	% Rank for EPR	Country	Religious Majority as % of Total Population	% Rank for Religion
Burkina Faso	1	0.866	Lesotho	99.9	0.980
Libya	1	0.866	Sau Tome and Principe	99.9	0.980
Lesotho	1	0.866	Swaziland	99.8	0.961
Somalia	1	0.866	Botswana	99.6	0.903
Swaziland	1	0.866	Namibia	99.6	0.903
Tunisia	1	0.866	Zambia	99.6	0.903
Tanzania	1	0.866	Tunisia	99.5	0.884
Eritrea	0.999	0.844	Morocco	99.2	0.865
Morocco	0.984	0.822	Mauritania	99.1	0.826
Madagascar	0.982	0.800	Zimbabwe	99.1	0.826
Botswana	0.982	0.777	Angola	99.0	0.788
Togo	0.937	0.755	Cape Verde	99.0	0.788
Mauritania	0.888	0.733	Madagascar	98.9	0.750
Guinea	0.864	0.711	Seychelles	98.9	0.750
Sierra Leone	0.859	0.688	Republic of Congo	98.6	0.711
Mozambique	0.834	0.666	Niger	98.6	0.711
Guinea-Bissau	0.828	0.644	Somalia	98.5	0.673
Liberia	0.817	0.622	South Africa	98.5	0.673
Niger	0.810	0.600	Comoros	98.3	0.653
Algeria	0.803	0.577	Rwanda	98.2	0.634
Chad	0.793	0.555	Burundi	98.0	0.596
Gabon	0.782	0.533	Algeria	98.0	0.596
Congo	0.771	0.511	Djibouti	96.9	0.576
Angola	0.768	0.488	Libya	96.6	0.557
Central African Republic	0.765	0.466	Equatorial Guinea	96.0	0.519
Gambia	0.752	0.444	Senegal	96.0	0.519
Senegal	0.752	0.422	Gambia	95.0	0.500

Country	Ethnic Polarization Score	% Rank for EPR	Country	Religious Majority as % of Total Population	% Rank for Religion
Ethiopia	0.745	0.400	Egypt	94.6	0.480
Benin	0.741	0.377	Kenya	93.0	0.461
Côte d'Ivoire	0.731	0.355	Mali	92.5	0.442
Nigeria	0.713	0.333	Central African Republic	91.1	0.423
Ghana	0.700	0.311	Gabon	90.5	0.403
Zimbabwe	0.689	0.288	Uganda	87.9	0.384
Zambia	0.687	0.266	Liberia	87.8	0.346
South Africa	0.680	0.244	Togo	87.8	0.346
Uganda	0.631	0.222	Malawi	87.2	0.326
Namibia	0.625	0.200	Guinea	84.4	0.307
Cameroon	0.609	0.177	Ghana	84.1	0.288
Malawi	0.576	0.155	Mauritius	83.4	0.269
Kenya	0.559	0.133	Cameroon	82.1	0.250
Rwanda	0.538	0.111	Mozambique	77.2	0.230
Burundi	0.511	0.088	Benin	75.6	0.211
Democratic Republic of Congo	0.466	0.066	Democratic Republic of Congo	75.0	0.192
Sudan	0.463	0.044	Sudan	71.3	0.153
Egypt	0.363	0.022	Sierra Leone	71.3	0.153
Mali	0.360	0	Tanzania	69.8	0.134
Comoros	.	.	Ethiopia	66.1	0.115
Cape Verde	.	.	Eritrea	63.5	0.096
Djibouti	.	.	Cote d'Ivoire	63.3	0.076
Equatorial Guinea	.	.	Burkina Faso	59.0	0.057
Mauritius	.	.	Guinea-Bissau	57.8	0.038
Sau Tome and Principe	.	.	Chad	55.8	0.019
Seychelles	.	.	Nigeria	50.4	0.000

Appendix C



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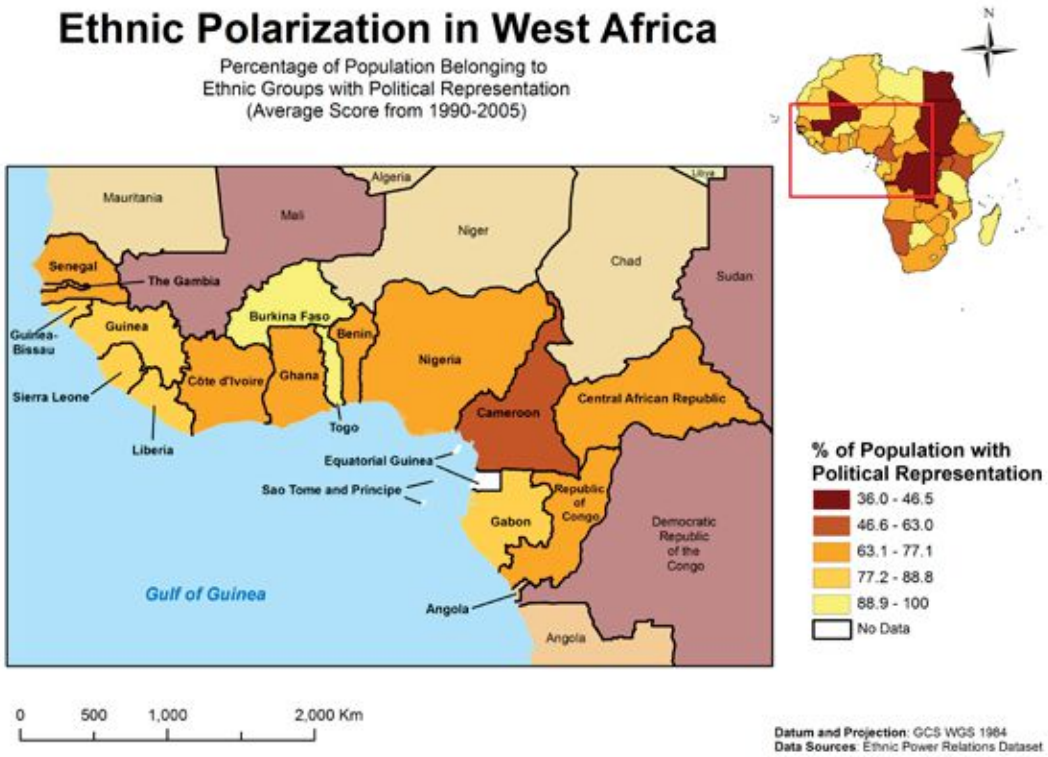

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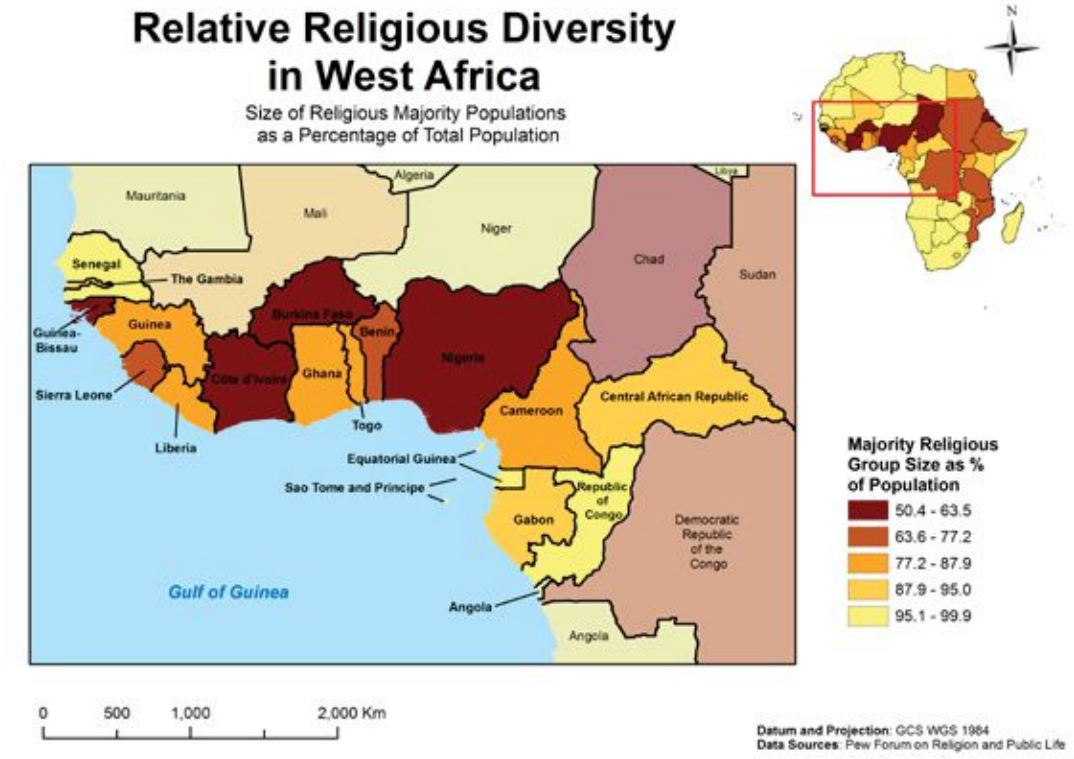

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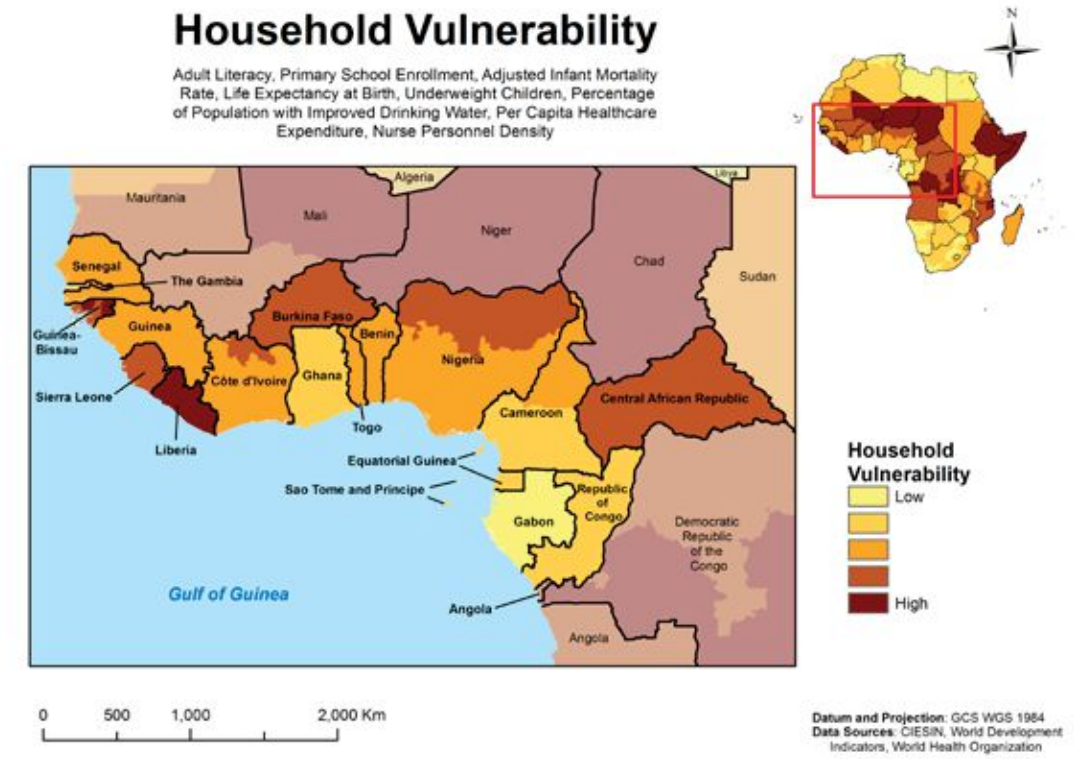
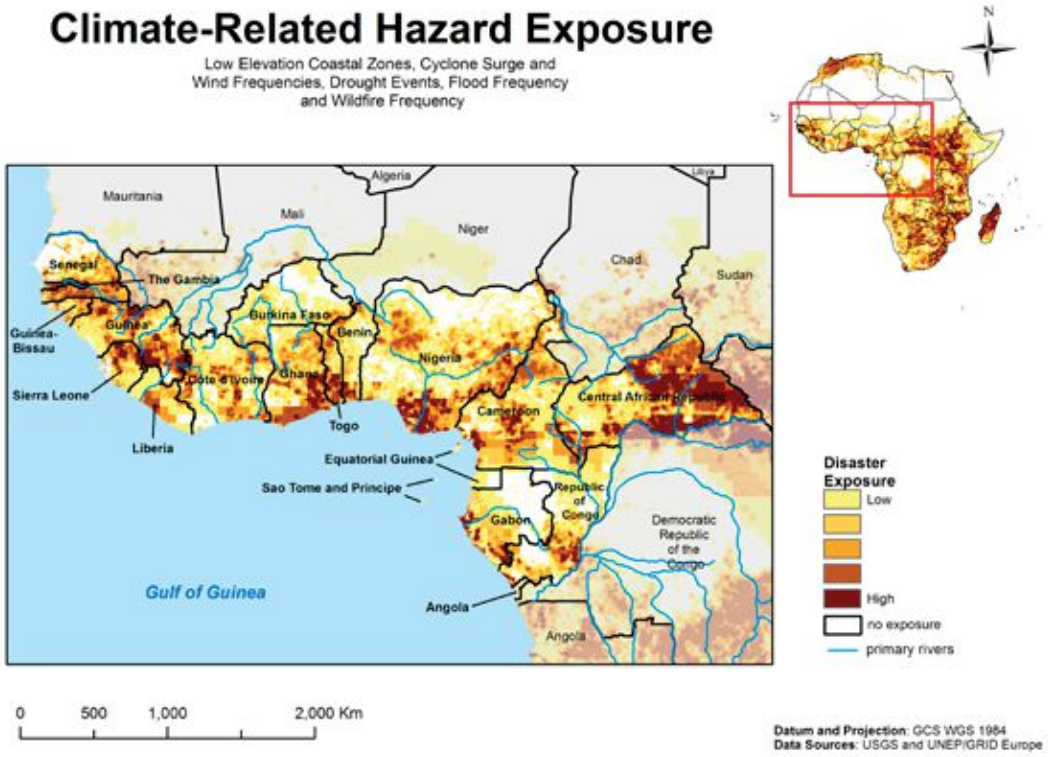
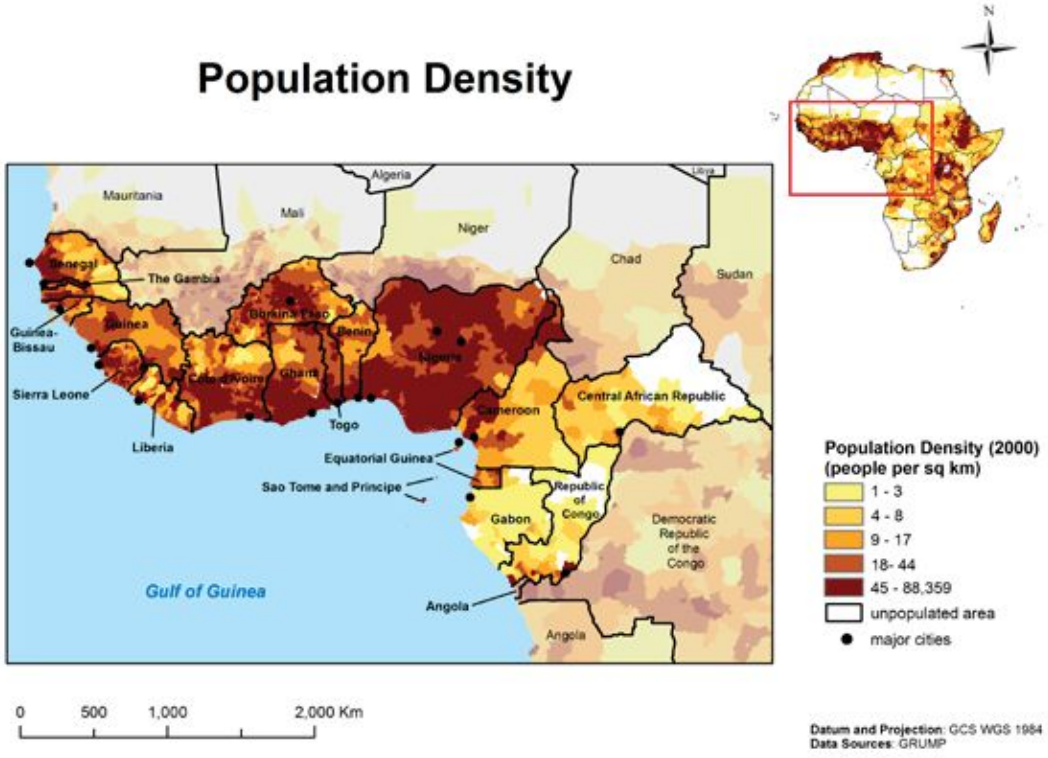


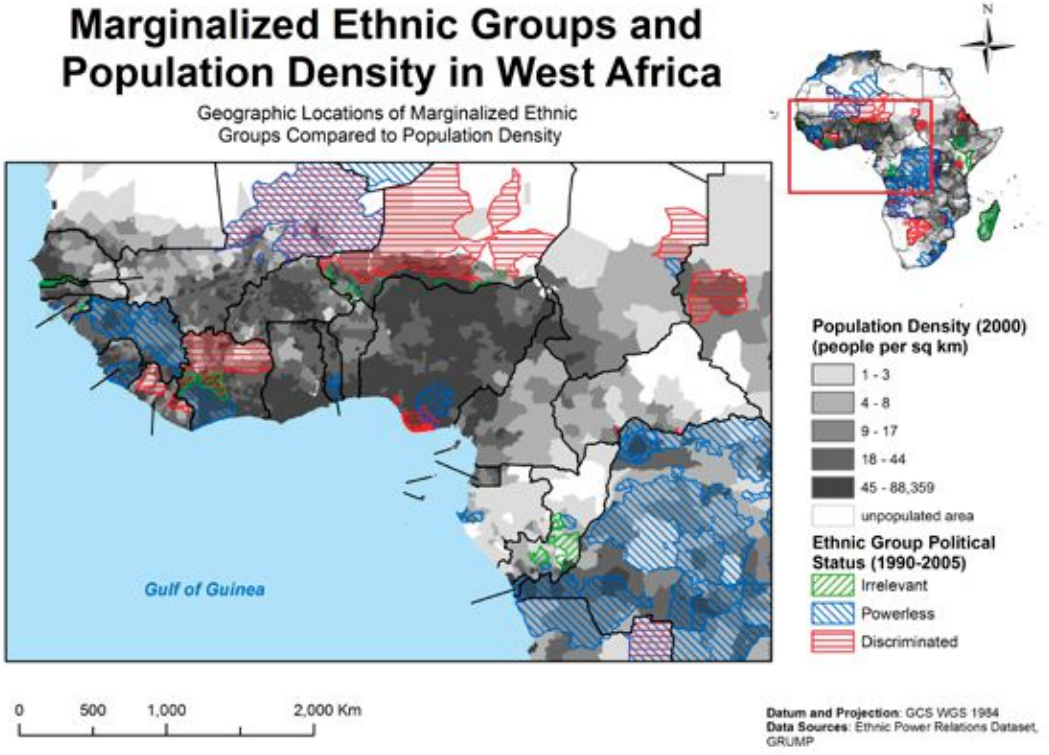
Appendix G



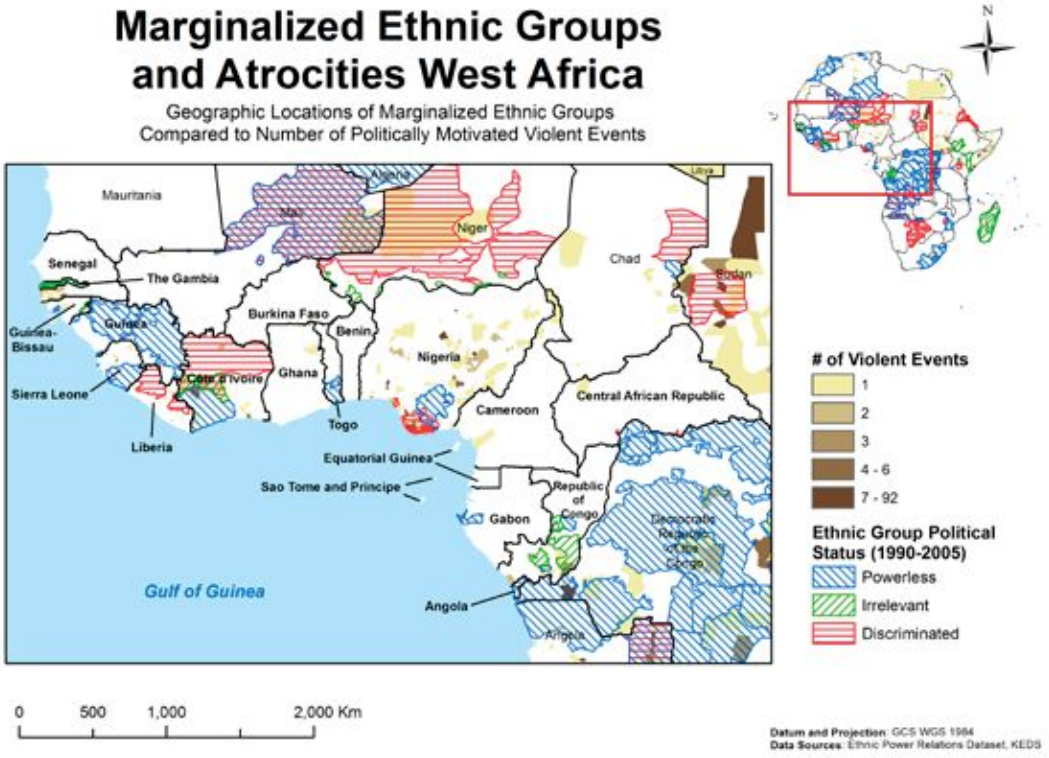
Appendix H



Appendix I



Appendix J



Appendix K. Nigeria Demographic Statistics

	State	Area (sq. km.)	Population (2006)	GDP PPP (2007)	GDP per capita	Pop. per sq. km.
1	Abia	4,900	2,833,999	8,687,442,705	3,065	578
2	Adamawa	38,700	3,168,101	4,582,045,246	1,446	81
3	Akwa Ibom	6,900	3,920,208	11,179,887,963	2,851	568
4	Anambra	4,865	4,182,032	6,764,219,562	1,617	859
5	Bauchi	49,119	4,676,465	4,713,858,180	1,007	95
6	Bayelsa	9,059	1,703,358	4,337,065,923	2,546	188
7	Benue	30,800	4,219,244	6,864,209,262	1,626	136
8	Borno	72,609	4,151,193	5,175,165,142	1,246	57
9	Cross River	21,787	2,888,966	9,292,059,207	3,216	132
10	Delta	17,108	4,098,391	16,749,250,544	4,086	239
11	Ebonyi	6,400	2,173,501	2,732,472,739	1,257	339
12	Edo	19,187	3,218,332	11,888,446,884	3,693	167
13	Ekiti	5,435	2,384,212	2,848,372,512	1,194	438
14	Enugu	7,534	3,257,298	4,396,590,769	1,349	432
15	Gombe	17,100	2,353,879	2,500,467,306	1,062	137
16	Imo	5,288	3,934,899	14,212,637,486	3,611	744
17	Jigawa	23,287	4,348,649	2,988,014,405	687	186
18	Kaduna	42,481	6,066,562	10,334,763,785	1,703	142
19	Kano	20,280	9,383,682	12,393,103,864	1,320	462
20	Katsina	23,561	5,792,578	6,022,655,197	1,039	245
21	Kebbi	36,985	3,238,628	3,290,847,166	1,016	87
22	Kogi	27,747	3,278,487	4,642,794,262	1,416	118
23	Kwara	35,705	2,371,089	3,841,827,534	1,620	66
24	Lagos	3,671	9,013,534	33,679,258,023	3,736	2455
25	Nassarawa	28,735	1,863,275	3,022,828,885	1,622	64
26	Niger	68,925	3,950,249	6,002,007,080	1,519	57
27	Ogun	16,400	3,728,098	10,470,415,017	2,808	227
28	Ondo	15,820	3,441,024	8,414,302,623	2,445	217
29	Osun	9,026	3,423,535	7,280,597,521	2,126	379
30	Oyo	26,500	5,591,229	16,121,670,484	2,883	210
31	Plateau	27,147	3,178,712	5,154,059,937	1,621	117
32	Rivers	10,575	5,185,400	21,073,410,422	4,063	490
33	Sokoto	27,825	3,696,999	4,818,615,261	1,303	132
34	Taraba	56,282	2,300,736	3,397,790,217	1,476	40
35	Yobe	46,609	2,321,591	2,011,499,081	866	49
36	Zamfara	37,931	3,259,846	4,123,829,498	1,265	85
	Federal Capital Territory	**7,607**	**1,405,201**	**5,010,968,012**	**3,566**	**184**
	Total	**909,890**	**140,003,182**	**291,019,449,704**	**2,078**	**153**

Source: National Bureau of Statistics (NBS) http://www.nigerianstat.gov.ng/nbsapps/annual_report.htm

*Southern States

**Northern States

Appendix K. Nigeria Demographic Statistics continued

	State	Literacy (15+)	Education Expend.	Mobile Phone	Television	Internet
1	Abia	89.3	223378	82	72.5	12.8
2	Adamawa	56.5	19922	41.8	29.1	2.1
3	Akwa Ibom	84.7	540946	71.8	62.3	4.3
4	Anambra	86.6	140933	85.1	77.9	16.2
5	Bauchi	62.4	4795	34.8	19.6	0
6	Bayelsa	81.8	76694	81.4	82.4	3.3
7	Benue	75.5	196398	64.9	40.8	3.2
8	Borno	51.1	32646	35.3	26.2	1.3
9	Cross River	77.5	179970	80	71.8	3
10	Delta	81	140274	78.4	64.5	6.6
11	Ebonyi	66.3	75114	56.1	32.5	2.1
12	Edo	86.7	235603	87.7	84.4	3.7
13	Ekiti	72.6	219253	77.9	51.2	3.8
14	Enugu	79.4	266616	71.7	51.3	8.4
15	Gombe	74.7	56417	52.7	43.3	2.1
16	Imo	82.7	239112	87.4	80.5	5.6
17	Jigawa	60.9	3931	53.9	22.2	3.9
18	Kaduna	61.7	105182	51.2	39.4	1.9
19	Kano	79.5	43228	45.8	31.2	3
20	Katsina	25.9	23005	20.4	19.4	0.2
21	Kebbi	24.9	12330	31.9	30.3	1.6
22	Kogi	64.8	60	67.9	48.9	3.6
23	Kwara	53.7	1310	72.7	61.4	6.4
24	Lagos	91.1	24120	97.1	94.9	15.7
25	Nassarawa	56.7	39738	36.8	29.2	0.3
26	Niger	41.3	10579	55.8	47.9	1.1
26	Niger	41.3	10579	55.8	47.9	1.1
27	Ogun	73.4	179733	84.7	59.1	13.3
28	Ondo	83.9	81199	87.7	65.8	3.5
29	Osun	75.7	62790	83.9	63.7	6.6
30	Oyo	70.1	181544	76.8	59.6	14.3
31	Plateau	71.3	86597	62.5	50.8	11.3
32	Rivers	89.6	109189	82.5	73.5	16.1
33	Sokoto	42.2	29664	36.7	30.2	0
34	Taraba	44.6	75137	31.1	16.1	0.6
35	Yobe	19.4	3831629	15	10	0.6
36	Zamfara	30.7	0	31.6	23.7	0.4
	Federal Capital Territory	**70**	**10015**	**83.6**	**67.7**	**15**
	Total	**66**	**104207**	**62.1**	**49.6**	**5.3**

Source: Annual Abstract of Statistics (2008) National Bureau of Statistics http://www.nigerianstat.gov.ng/nbsapps/annual_report.htm

*Southern States

**Northern States

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