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14. ABSTRACT

Water scarcity is a global concern due to the potential for conflict when competition over diminishing water resources occurs at the local and regional level. A potential complicating factor to the problem of water scarcity is the instability of a nation due to the ineffectiveness of the central government to provide societal resiliency to the populace. This research paper focuses on the nations of Mali and Yemen as case studies for both water scarcity and interrelated state stability issues. Water scarcity is discussed in three manifestations; natural causes, human interaction causality, and combined natural causes and human interaction. Stability, is linked to the Fragile States Index (FSI) produced by the Fund for Peace (FFP). The FSI uses political, social, and economic indicators to determine an overall state level of stability. Key stability factors explored in the case studies of Mali and Yemen include sanitation, agricultural practices, and migration trends as related to signs of instability and both current and future water scarcity. The case studies of Mali and Yemen are assessed to analyze both the similarities and differences between the countries and how the elements of water scarcity and state stability relate to the thesis statement.

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MASTER OF MILITARY STUDIES

TITLE: Water Scarcity and Interrelated Stability Issues: The Cases of Mali and Yemen

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DISCLAIMER

Executive Summary

Title: Water Scarcity and Interrelated Stability Issues: The Cases of Mali and Yemen

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Thesis: Water scarcity impacts can be amplified in a state with instability as there is less government or public means to manage water resources or intervene and prevent conflict over water access.

Discussion: Water scarcity is a global concern due to the potential for conflict when competition over diminishing water resources occurs at the local and regional level. A potential complicating factor to the problem of water scarcity is the instability of a nation due to the ineffectiveness of the central government to provide societal resiliency to the populace. This research paper focuses on the nations of Mali and Yemen as case studies for both water scarcity and interrelated state stability issues. Water scarcity is discussed in three manifestations; natural causes, human interaction causality, and combined natural causes and human interaction. Stability, is linked to the Fragile States Index (FSI) produced by the Fund for Peace (FFP). The FSI uses political, social, and economic indicators to determine an overall state level of stability. Key stability factors explored in the case studies of Mali and Yemen include sanitation, agricultural practices, and migration trends as related to signs of instability and both current and future water scarcity. The case studies of Mali and Yemen are assessed to analyze both the similarities and differences between the countries and how the elements of water scarcity and state stability relate to the thesis statement.

Conclusion: Research for this paper has shown that state instability can provide the opportunity for conflict over water resources as security within the populace is low or nonexistent. The research for this paper has not shown water scarcity leading to conflict past the local level, but the potential exists with transnational water bodies and both competing ethnic and religious factions.

Introduction

This paper researches the relationship between sustained regional water scarcity and interrelated stability issues. As the global population increases, the impacts of water scarcity will continue to intensify. "Globally, nearly 2.1 billion people lack access to safe drinking water in their homes and about 4.4 billion lack access to proper sanitation, putting them at risk of disease."[1] The countries of Mali and Yemen serve as two case studies that demonstrate how water scarcity and state instability are related. A state refers to the sovereign boundaries of a nation as recognized by the international community. The challenge in determining the relationship between water scarcity and state stability is assessing if one variable is a direct result of or the by-product of the other variable. Water scarcity impacts can be amplified in a state with instability as there is less government or public means to manage water resources or intervene and prevent conflict over water access.[2] Water scarcity and state stability are defined below and the interaction between both topics is explored for each case study, followed by an assessment of the case studies.

Water Scarcity

Water scarcity is when a state, area within a state, or the region in which a state resides does not have enough water to support the needs of the inhabitants. **"**Water scarcity can mean scarcity in availability due to physical shortage, or scarcity in access due to the failure of institutions to ensure a regular supply or due to a lack of adequate infrastructure."[3] Water can be defined in terms of being a renewable resource, or not, as based on the rate of replenishment from naturally occurring phenomenon such as rain. "Groundwater and surface water, such as the average flow of rivers on a yearly basis, are considered renewable water resources, whereas deep aquifers, which do not have a significant replenishment rate on the human time scale, are deemed

non-renewable water resources"[4] Water scarcity has root causes that are; naturally occurring, the result of human interaction, or natural causes that are being compounded and accelerated by human interaction.

Water Scarcity: Natural Causes

Natural causes of water scarcity include climate variation and cyclical climate change. Climate variation is typically thought of from months to decades. Weather events that comprise climate variation are not necessarily sustained events or an indication of a cyclical climate. Climate variation significantly impacts local populations that do not have sufficient counter-measures to address seasonal or multi-seasonal weather impacts. One example is the inability of the terrain, whether due to slope or the lack of subsurface features like aquifers, to capture and contain water from the resultant floodwater of heavy rain. Another example of climate variation is severe drought occurring during a season or over multiple seasons that impacts the water resiliency needed to sustain the local populace, livestock, and crops.

Cyclical climate change is viewed through a geological time scale, referring to eons, eras, epochs, and ages, that last for thousands and millions of years as opposed to decades or centuries. The changing climates of continents due to the shifting of the tectonic plates over millions of years is an example of cyclical climate change whereas the melting of glaciers and diminishing of the polar ice caps over the past few decades serve as a representation of climate variation. The geological record has shown that regions alternated between wet and arid states of being. Regions of the world have sustained water scarcity concerns resulting from the historical physical shifting of desert belts. Shifting deserts have been observed through the geological record as evidenced in regions that are currently experiencing water scarcity. For example, "Across the various geological epochs, the climate of the Arab countries has fluctuated between

dry and humid eras, the former leading to the creation of the Great Sahara in North Africa and the Empty Quarter in the Arabian Peninsula."[5] The current shifting of the Sahel serves as an example of a regional phenomenon that has been observable through geologic time scales.

Regardless of weather patterns occurring over vast periods or relatively short timeframes, such as experienced with climate variation, local populations may experience increased water scarcity and hardship.

Water Scarcity: Human Interaction Causality

Human interaction with the natural environment can cause water scarcity in a region by rapidly depleting limited water resources or altering natural water flow patterns. The human interactions that may result in water scarcity shall be addressed in the following topical order; boundaries, agreements for the damming of rivers, agricultural practices, population growth, and urbanization.

Competition over shared water resources along boundaries can occur at varying scales, from internal to a country or between two or more nations. Shared water resources include lakes, rivers, and underground aquifers that may in some cases cross political boundaries. Historical political boundaries were frequently established without regard to water resources, particularly subsurface water. Aquifers can span international boundaries and become a significant source of competition if consumption outpaces the ability of an aquifer to replenish through natural means of rain water absorption and underground water flow. "If groundwater abstraction exceeds the natural groundwater recharge for extensive areas and long times, overexploitation or persistent groundwater depletion occurs."[6] Some global regions have severely limited surface water and must heavily rely on aquifers as the primary water source. Historical political and physical boundaries did not factor the effects of future man-made dams.

The damming of rivers leads to increased water loss from the creation of reservoirs which can cause tension amongst populations below the dam that historically relied upon consistent water flow. The drying of downstream aquifers can also serve as a potential for conflict as a region experiences acute water scarcity. Environmental changes due to reduction of water flow that can lead to an increase in some diseases like schistosomiasis. Dams have been constructed without consideration of the sensitive natural cycles that maintain fresh water. An example of disturbing a natural riverine cycle is restricting the natural predators that eat the snails which cause schistosomiasis outbreaks. Many schistosomiasis cases could have been prevented by reviewing and implementing dam construction guidance published by the United Nations (UN) in the 1950s that accounted for predators moving past dams and eating downstream snails instead being restricted to reservoirs.[7]

Agreement-based factors of water resource competition include water resource management through international policy and law, a lack of official policy or law, or a failure by one or more parties to honor the conditions set by policy or law. Rivers are of great concern as the flow of water to nations downriver can become reduced in both quantity and quality due to the scheduling of dam releases and agricultural pollution through the runoff of chemicals. Hydroelectric dams not only provide the host nation with electricity, but the dam also creates reservoirs capable of storing water and restricting historical or agreed upon flows. “International institutions will play critical role in efforts to promote water cooperation and avoid conflict”[8] Governing bodies with fair representation of all stakeholders and impartial boards typically reduce conflict as there is more collective institutional knowledge to the agreed upon terms and conditions than a bilateral agreement.

Upstream agricultural practices greatly impact the quality of life for people reliant upon farming, fishing, and herding animals. Extensive irrigation for upstream crops diminishes riverine water flow rates and the ability to irrigate crops downstream. Pollution from pesticides and excessive fertilizer leads to algae blooms and undrinkable water downstream. Pollution decreases biodiversity within rivers and wetlands which causes imbalances in natural predator and prey cycles, to include limiting the amounts of aquatic food sources available to fishermen. Water logging is an agricultural practice of concern as it denies air from enriching the soil and causes soil salinization due to the inability to leach away salts in flowing water.

Population growth is a major factor in increasing global water scarcity, especially in regions that already have difficulty in supporting the water needs of the populace. The population growth and depletion of ground water in the Middle East has been observed and commented on by Robert D. Kaplan. “In three decades covering the Middle East, I have watched it evolve from a largely rural society to a realm of teeming megacities and in the next 20 years, the Arab world's population will nearly double while supplies of ground water will diminish.”[9] Many nations within arid and semi-arid environments are expected to experience population growth rates that will heavily tax or possibly negate natural resources such as water and cause local food insecurity. “The populations of more than 50 countries will increase by more than a third (some by more than two-thirds) by 2025, placing additional stresses on vital natural resources, services, and infrastructure.”[10] Water for drinking and sanitation are not the only concerns. Agriculture utilizes vast amounts of water to feed increasing populations, especially in historically water scarce regions and developing nations with limited irrigation means. “Global population growth projections of 2 to 3 billion people over the next 40 years, combined with

changing diets, are expected to increase food demand substantially by 2050."[11] The effects of water scarcity are often most notable in urban areas.

The global trend of urbanization, population shifts from rural areas to urban (city) areas, continues and is occurring faster in developing nations. "In 1950, 30 per cent of the world's population was urban, and by 2050, 66 per cent of the world's population is projected to be urban."[12] The promise of work, education, modern conveniences, and other benefits have enticed many people to leave rural areas, nomadic lifestyles, and traditional activities such as sustenance farming and animal herding. The large influx of people to urban centers has resulted in the formation of slums on the outskirts of cities where people are forced to live in close confines with large concentrations of people, making the risks of communicable disease and violence greater. Another concern for slums is that city infrastructure like running water is not extended to inhabitants and the lack of potable water results in poor sanitary conditions.[13]

Water Scarcity: Combined Natural Causes and Human Interaction

Desertification and deforestation are frequently a direct result of the interaction between natural and manmade environmental changes that leads to water scarcity. Desertification may occur naturally, but it may also be directly caused by--or intensified from--human interaction with the environment. The process of desertification begins with the loss of topsoil due to several factors, including wind erosion, poor agricultural practices and deforestation. Deforestation can increase soil erosion by removing natural wind barriers and root systems that prevent the compaction of soil. Compacted soil does not readily absorb rain for aquifer regeneration and causes surface erosion through water runoff. The effects of deforestation on desertification are more detrimental in arid regions since the environments lack resiliency. "Since growth of vegetation is approximately proportional to rainfall, dry areas take much more time to recover

from habitat destruction than do wet areas."[14] Regions experiencing water scarcity, naturally occurring or man-made, may have greater negative impacts depending of the level of state stability.

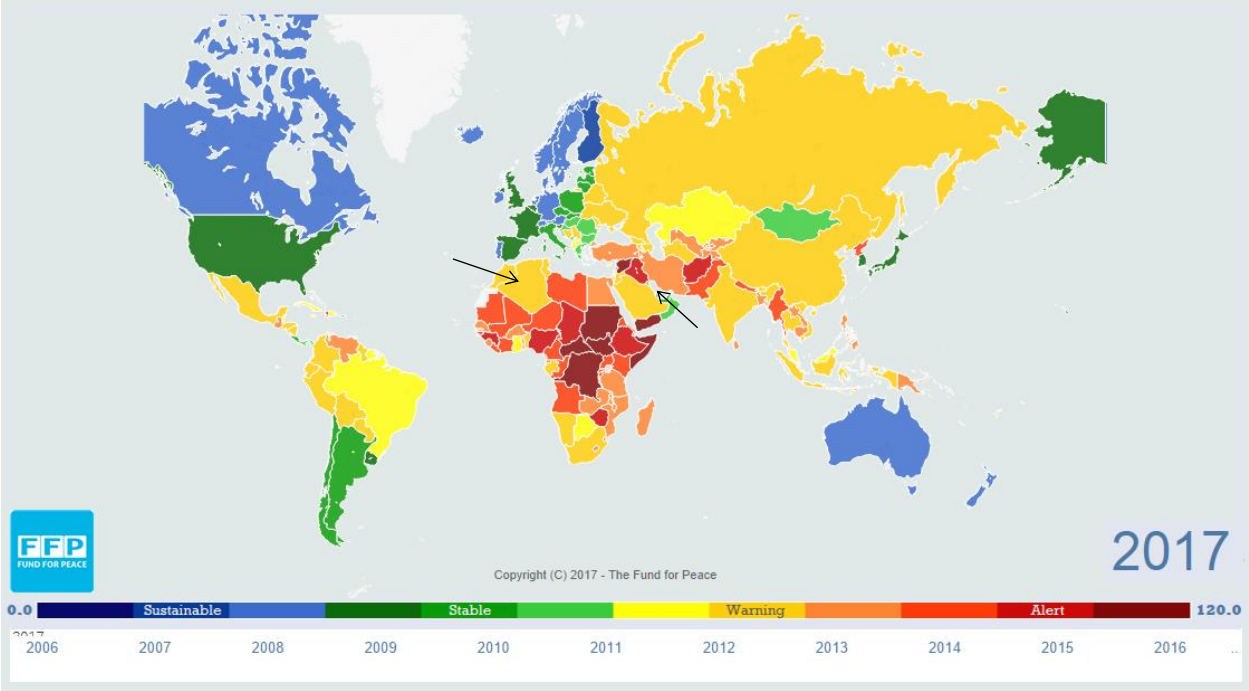
State Stability (Security)

The problem statement of this paper addresses the relationship between water scarcity and state stability. This section seeks to better define the concept of state stability to demonstrate the negative consequences of water scarcity across economic, social and political dynamics. State stability, will be linked to the Fragile States Index (FSI) annual report produced by the Fund for Peace (FFP). The FSI has replaced the Failed State Index, which had previously been the benchmark for assessing state stability.

The FSI uses political, social, and economic indicators to determine an overall state level of stability. The "state score" is generated by comparing the varying degrees of fragility factors (negative) and resiliency factors (positive). Political indicators include state legitimacy (integrity), public services, human rights/rule of law, security apparatus, and requirements for foreign intervention.[15] Social indicators include demographic pressures (population density relative to resources), the presence of and capacity to support refugees/internally displaced persons (IDPs), and group grievances with the potential for violence (ethnic, religious, and sectarian).[16] Economic indicators factored into the FSI are uneven economic development (group-based) and poverty/economic decline (measurements: per capita income, GNP, economic deficit, unemployment, poverty levels, business failures, and inflation).[17]

The previously mentioned stability indicators are inherently connected to water security and the ability to cope with current or future competition over water resources. The following

concerns of sanitation, agriculture, and migration are all related to state instability and can serve as indicators of current and future water scarcity.



Map representing the twelve ratings of the Fragile State Index (FSI).[18]

Sanitation and the spread of disease has become a growing social concern as urbanization continues to increase. The dense concentration of people that reside in cities, especially slums and shanty-towns on the outskirts, present a population susceptible to disease and the situation intensifies when there is a scarcity of potable water for drinking, bathing, and carrying away human waste. "Poor water quality and inadequate sanitation translate directly into a whole host of life-threatening illnesses including, but not limited to, diarrheal diseases such as cholera and dysentery, as well as typhoid fever, viral Hepatitis A, and dengue and dengue hemorrhagic fever, each of which disproportionately targets the young."[19] Potable water for drinking and sanitation are at extreme risk in areas that rely upon aquifers that cannot replenish at rate to meet the usage

by an ever-increasing urban population. Aquifers are also at risk of contamination from polluted runoff and poorly maintained access wells. This is a social concern as basic human needs are not met and become a political concern if the affected population faults the government's inability to address the situation.

Agricultural economic impacts to state stability can be brought on by sustained periods of drought that lead to localized famine as natural and man-made irrigation can no longer support agriculture. The loss of large agricultural areas in one country can result in pricing spikes for other countries that need to import foods from different markets. The price spikes in food staples can lead to localized food security concerns when the importing populace can no longer afford to feed itself.

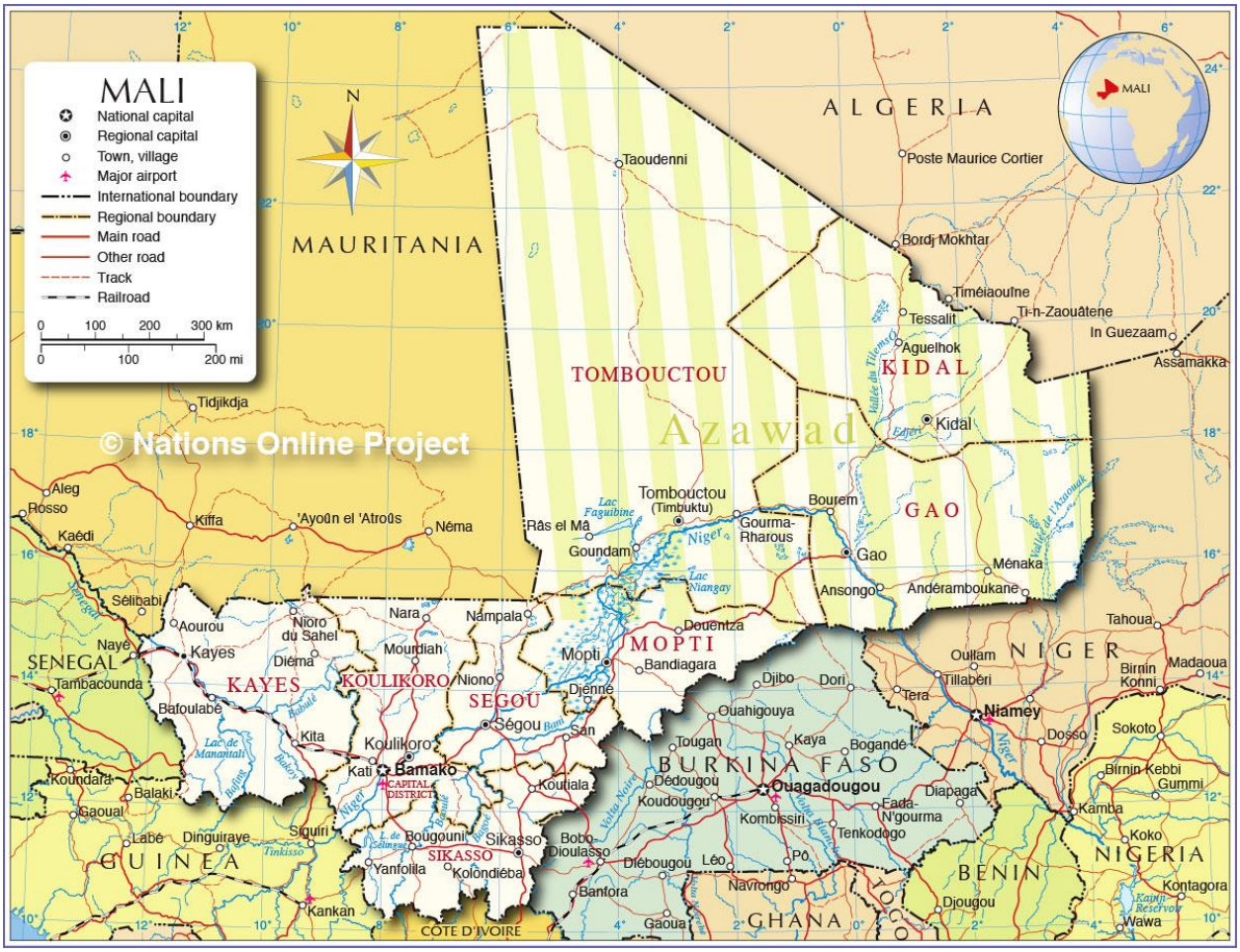
One social and economic concern in arid areas is the method used to prepare soil for agriculture. Traditional agricultural has given way to technology in some arid regions to keep up with the food demands of growing populations. The short-term benefits of technologically advanced agriculture can carry long-term detriments to the local environment. "Many of these technologies (agricultural), particularly in ploughing, are inappropriate to arid and semi-arid lands as they cause soil to decompose and disintegrate, rendering it vulnerable to erosion."[20] Topsoil erosion greatly increases the risk of desertification. Land with no topsoil can't support farming necessary to feed the local populace and serve as a source of income through agricultural sales.

Migration impacts from water scarcity can cause insecurity by displacing other populations that are internal and external to the state. Sudden weather events such as floods and the local failure to plan for and mitigate weather effects contribute greatly to displacement. Sustained climatic events such as drought and desertification feed the continual flow of refugees

abroad and IDPs. “An average of 22.5 million people have been displaced each year by climate or weather-related disasters in the last seven years (2008-2015) - equivalent to 62,000 people every day.”[21] Many host nations have a difficult time in sustaining support to refugees as the indigenous populace faces resource issues such as water scarcity and the impacts on both food production and the environment. Without the ability to provide host nation oversight, refugees may illegally occupy private or government lands and decimate forests and grazing land, consume water, produce waste to the detriment of the local population.[22] Political concerns arise as host nations have threatened forced repatriation of displaced people to their country of origin due to rising tensions.

The following case studies of Mali and Yemen will examine natural and man-made water scarcity concerns and elements of state instability to include conflict, migration, and the effects of weak central governance. The factors of water scarcity and state instability will be assessed for each case study separately and then compared to determine if stability dynamics are consistent.

Case Study 1 – Mali



Graphic 1: Political and Administrative Map of Mali[23]

The Republic of Mali has internal and regional security concerns resulting from both naturally occurring and man-made water scarcity. The 2017 FSI rated Mali as being in "alert" status, which is third from the worst possible FSI rating. The FSI showed Mali as demonstrating improvement but with the following caveat. "Though Mali was among the most improved for the year, the longer-term trends suggest that improvements over the past year are more likely bounce backs from earlier shocks rather than evidence that overall pressures in the country are

decreasing."[24] Failure by the government of Mali to stem the negative impacts of diminishing water supply and provide equal water access to all ethnicities will result in escalated security concerns to the nation-state of Mali and the greater Sahel region.

The Republic of Mali is a landlocked nation located in northwest Africa and is part of the greater Sahel region. The Sahel region extends between the east and west coasts of Africa and is a transition zone between the Sahara Desert to the north and savanna regions to the south (see graphic 1). Mali relies on two major rivers, the Senegal and Niger, and wetlands that are fed by the rivers' flood waters during the rainy season. Although Mali's water resources will not grow its population of 17,885,245 is expected to double by 2035.[25] The case study will examine both natural and man-made causes of water scarcity and state stability issues, such as conflict and migration. The interaction of water scarcity and state instability will be analyzed as it applies to Mali and the greater Sahel region.

Water scarcity concerns impacting the Republic of Mali result from mostly natural factors to include cyclical weather patterns, drought, and desertification. The cyclical nature of the greater Sahel weather pattern causes reliance upon a brief rainy season to replenish water levels in the rivers and to supply water, along with fish and nutrients, to the wetlands. "Sahelian wetlands rely on flood flows down rivers during a short rainy season lasting from June to September."[26] The economy of Mali is at risk from increasing water scarcity. "Agricultural production remains the foundation of the Malian economy with 80 percent of the population relying upon agriculture for their livelihood."[27] Weather patterns in recent decades have shifted negatively for both Malian farmers and pastoralists as water has become less abundant for longer periods of time. "Mali's average rainfall has dropped by 30 percent since 1998 with droughts becoming longer and more frequent, according to a 2013 study by the United States (U.S.)

Army's Strategic Studies Institute."[28] Mali has water scarcity concerns from desertification that results from the historical shifting of the Sahel from North to South that is part of a greater expansion of the Sahara Desert into Mali. The current rate of desertification is at a rate of 48 kilometers a year, forcing whole communities to migrate and pushing them on to land occupied by other groups.[29]

Desertification, hydropower dam projects and abstraction are three of the major man-made impacts increasing water scarcity to many Malians and neighboring countries, especially in rural areas. Desertification, already occurring naturally in the north, has been accelerated in southern portions of Mali due to deforestation. Deforestation has increased soil erosion by removing wind barriers and root systems that prevent the compaction of soil. Compacted soil does not allow for regular absorption of rain and causes further surface erosion through surface water runoff. Hydropower dam projects have been considered by some regional groups as successes for the creation of electricity and initiating scheduled water releases during the dry season for better controlled irrigation near urban centers. The most negative aspect of hydropower dams in Mali and the greater Sahel region is the disruption of the natural and necessary flow of flood waters during the rainy season that provide water to the wetlands.

The Inner Niger Delta that extends into southern and central Mali is an essential wetland area utilized by fishermen, rural farmers, and nomadic herders alike. The controlled irrigation afforded to urban areas has systematically diminished the flow to rural downstream wetlands. Disproportional access to farmable and pastoral land, along with diminishing wetland area, has led to security concerns between ethnic groups and highlighted the divide between rural and urban Malians. "The stable social structures that ensured harmonious use of the Delta's resources

have been fractured, as Fulani herders dispute with farmers over the available wetlands and pastures."[30]

Recent stability concerns in the Republic of Mali stem from the fallout of the 2012 conflict between the Government of Mali and Tuareg separatists that allowed for a permissible environment to terrorist groups, such as Al-Qaeda, and necessitated an international military intervention in 2013. Security concerns in Mali were further exasperated by a 2012 coup that transplanted the existing national government with the Malian Military. "In April 2012, the Tuareg (Mouvement National de Libération del' Azawad, MNLA) and jihadist armed groups took advantage of the political vacuum caused by the coup and captured the north of the country."[31] The conflict began with assertions by the Tuareg and other northern Malian groups that they received poor recognition and services from the Government of Mali based on ethnicity and location. "The attacks, and the failure to disarm thousands of combatants from Mali's 2012-2013-armed conflict, deepened a security vacuum, creating a precarious human rights climate for civilians in central and northern Mali."[32] Water scarcity in the northern sections of Mali have been attributed to ethnic conflict as armed groups of nomadic herders from the water scarce north forcibly moved into central and southern parts of Mali to gain water access for their animals. "Tensions boiled over in 2012, when Islamist groups from the country's north rebelled against the government and invaded the delta."[33]

The Government of Mali, both before and after the 2012 coup, failed to establish stability in Mali and thus failed to provide or enable essential services such as water distribution and dispute resolution. The lack of internal security in Mali, accompanied by regional instability created a void for government-led resource management. "Last year (2014), the Brookings Institute published a study showing that the frequency of cross-border violence grows by four

percent, while inter group violence - the kind seen in Mali - rises 14 percent for each percentage change in average temperature and rainfall."[34] International aid was greatly reduced by the 2012-2013 conflict as many nongovernmental organizations (NGOs) fled Mali and could no longer assist the Malian government to execute essential functions such as water and fuel distribution. The security void during the 2012-2013 Malian conflict resulted in NGO and government issued water pumps being stolen or ruined by having to rely on inferior fuel. "Moreover, in some towns, water pumps were stolen by the rebels, making irrigated rice cultivation impossible."[35] The displacement of Malian citizens due to water scarcity from diminished security environments has resulted in an exodus of people within Mali to as far away as Europe.

Within Mali, IDPs have resulted from lands becoming more arid or areas of conflict that prevent safe access to water resources. "As a legacy of the March 2012 coup d'état and violent conflict, 135,000 Malians remain as refugees in neighboring countries, 86,000 Malians are internally displaced, and approximately 1.9 million people required sustained emergency food assistance in 2014."[36] Both internal Malian violence and basic needs like water access have caused groups of people to relocate to areas like the Inner Niger Delta and apply further stress on the diminishing resources present. "Moving to safer areas led to the degradation of grazing and watering points, given the limited carrying capacity of the host regions."[37] Mali's lack of state resiliency has made it difficult to support incoming refugees and has generated Malian refugees displaced internally and in other countries.

Displaced persons from other neighboring countries that are entering Mali increase stress on the local environment and risk conflict with the local populace. "Herders from other regions, and even neighboring countries such as Algeria and Niger, are moving onto territory mostly Tuareg community uses for grazing." The immigration of foreigners onto Tuareg lands for

herding purposes further increases the conflict between the Tuareg and Government of Mali, as the Tuareg have historically insisted the Government of Mali does not support Tuareg rights or lands. A hydropower project in Mali has had significant negative effects on the people of Senegal by reducing waters reaching wetlands. Many rural citizens of Senegal have historically relied on the natural flow of river water to nourish wetlands, as they do in Mali. The accounts of a local teacher from a riverside village in Senegal illustrate the local impacts from damming. "The river had a flood that watered wetlands where fish grew, but now there is no flood because of the Manantali Dam upstream in Mali, causing around 100 people to leave the village, and in some villages, they are almost all gone."[38]

Refugees from Mali have put a strain on the often-scant resources in neighboring countries, resulting in an increased likelihood of conflict; to include ethnic violence and forced repatriation back to water scarce portions of Mali. Some Malians have joined the flow of people from the Sahel region to Europe. Many young adults from Mali and the greater Sahel region are leaving the villages and cities as the traditional way of life is becoming too difficult to maintain as economic uncertainty causes unemployment and difficult daily existence.

One difficulty of traditional life is the collection and treatment of water. Some rural regions require Malians to walk long distances and carry water back to their home. Water must be boiled for consumption and the process requires the collection of firewood or purchase of a fuel source. River water is not clean enough to wash clothes or bathe in for fear of disease. "Women who must use river water to wash clothes and people who must use the river to bathe are at risk of infection of this dreadful disease (Schistosomiasis) among others."[39] There is not enough water in some areas of Mali to have sufficient sanitary practices and minimalize the risk of diarrheal diseases. "It is already clear that diarrheal diseases will decrease when clean

drinking water is available."[40] Jobs in Europe pay more, and the monies can be sent to family members to aid their situation in Mali or other countries within the Sahel. This has created a void in able bodies and fresh perspectives to work with the government, NGOs, and international governments in implementing plans such as new water management practices and education on water sanitation practices.

The situation in Mali remains of concern to the United States Government (USG), as the U.S. has maintained diplomatic relationships with the Republic of Mali since the country gained independence from France. The U.S. has continually sought to maintain a regional democracy and provide economic support to better the welfare of Malian people. "U.S. foreign assistance is administered through a whole of government approach that includes but is not limited to the long-standing in-country presence of the U.S. Agency for International Development (USAID), the Centers for Disease Control (CDC), the National Institutes for Health (NIH), and the Department of Defense (DoD)."[41] The U.S. continues to provide significant funding for support efforts in Mali as there could be dire circumstances for Mali and the Sahel region should U.S. and other international support wain. "U.S. foreign assistance to Mali totaled more than $125.1 million in FY 2016 with $117 million officially requested for FY 2017."[42] Potential fallout in Mali from diminished international support could result in more regional instability with regards to decreased security, poor regional cooperation, and failure to meet the most basic needs of the Malian people.

Mali could provide a more substantial vacuum for terrorist groups to maintain headquarters, recruit from the local populace, and conduct nefarious operations within Mali and the greater Sahel region. "In the north there is such poverty, the environment is so tough, that when the jihadists come they find it easy to get followers," said Paul Coulibaly, a senior adviser

to Mali's agriculture ministry."[43] The tumultuous security environment has not remained solely in the north of Mali and threatens to extend throughout the country and across international borders. "Malian civilians endured a situation of "no war, no peace" in 2016, as implementation of the previous year's peace accord to end the military and political crisis in the north stalled, and armed groups linked to Al-Qaeda launched dozens of attacks on Malian security forces and international peacekeepers, extending their operations south."[44]

To ease the issues of water scarcity and the potential conflict associated with water access, the Government of Mali must make strides in both internal and regional efforts. The Government of Mali must first establish stability through internal security. A functioning and inclusive multi-party government would enable ethnic tensions to be discussed and worked upon transparently in a collaborative environment. Effective government handling of ethnic and regional issues within Mali would lessen real and perceived tensions, such as the Tuareg perception of marginalization from the government. Stability throughout all of Mali would allow the government, international government agencies, and NGOs to work towards solutions that better support the basic needs of Malian people. Having essential water needs met for Malians, especially in the arid north, would reduce internal conflict by keeping northern groups from making incursions into central and southern Mali for water and grazing fodder. A secure northern Mali would help reduce the ease of recruitment by terror organizations of maligned Malians that hold an oppositionist view of the government of Mali.

The Government of Mali must also work successfully with other governments in the region to stem the flow of IDPs and the shifting demand on dwindling resources by ensuring basic needs like water access are both agreed upon and met. A regional approach is needed as Sahel rivers and wetlands span multiple countries and are vital to each one. Regional efforts for

wetland conservation could help preserve the rural populace and help maintain traditional ways of life for the various cultures. An example of the need for strong regional governance includes the effects of existing and proposed hydropower dams. Plans for a hydroelectric dam upstream in Guinea could cause large areas of the wetlands to dry up in drier years, triggering a mass exodus from the Inner Niger Delta region.[45] Hydropower dam benefits for urban populations must be weighed against the negative impacts on rural farming populations, nomadic herders, and to the greater Sahel ecosystem.

Water scarcity in Mali must be addressed as both a cause and result of poor security environments. Conflict can result from competition over access to water and water related resources; to include farm land, pastoral land, and fishing habitat. Conflict and the resulting threat environment can prevent Malians from accessing traditional water sources, causing displacement to other areas and straining indigenous resources to the point of creating additional conflict. The Government of Mali must provide legitimate and inclusive governance to the entire populace and set conditions for organic and international efforts to manage and reduce the levels of water scarcity and meet other basic needs.

The country of Yemen serves as the next case study where conditions of water scarcity and state stability will be analyzed for correlations. The case studies of Mali and Yemen will then be assessed against each other to validate the initial problem statement of whether water scarcity impacts are amplified in a state with instability and weak governance.

Case Study 2 – Yemen

Graphic 2: Political Map of Yemen[46]

Yemen is a Middle East nation bordered by Saudi Arabia to the north and Oman to the east. The Red Sea comprises Yemen's western boundary and the Gulf of Aden is the southern border. The 2017 population of Yemen was 28,036,829 with an annual growth rate of 2.28% that is currently unsustainable due to water scarcity, food insecurity, and continued conflict that restricts state development.[47] Yemen is an arid nation with no major rivers or significant bodies of fresh surface water. The population is reliant on sub-surface aquifers that are accessed by

wells. The failure to maintain a legitimate government in recent years has resulted in a destabilized state that cannot manage the scarce remaining water resources.

Consumption of fresh water resources in Yemen continue to outpace the available water, causing the water tables in aquifers to drop precariously. “The gap between annual water resources (2.5 billion cubic meters or BCM) and annual water consumption (3.4BCM) is estimated at 0.9BCM, a considerable shortfall that is ‘remarkably’ considered to be compensated by groundwater.”[48] Rain water collected by spate irrigation in ravines or channels that are dry outside of a rainy season (*wadis*), retention dams, and desalinization account for the other local sources of water used by Yemen’s population. “Yemen ranks among the top 5 most water scarce countries in the world.”[49] The trend for water scarcity has steadily increased and is nearing equal proportions between the urban and rural populations. From 1990-2004, the percentage of Yemenis that had access to water decreased from 71 to 67.[50] The majority of people in Yemen claim agriculture as their livelihood, with most estimates showing 60 percent of the population as farmers. The reliance of agriculture in Yemen results in significant use of the aquifer systems for irrigation, thus reducing water resources for drinking and sanitation purposes. “In Yemen, irrigated agriculture consumes more than 80% of the total annual groundwater that is abstracted through more than 70,000 wells throughout Yemen.”[51]

The 2017 FSI rated Yemen as being in “very high alert status”, which is the worst possible category shared by only five other countries (Sudan, Syria, Central African Republic, Somalia, and South Sudan). Yemen is a poor nation and its gross domestic product continues to decline as oil reserves are diminishing and continued civil unrest and instability creates unemployment and destroys infrastructure. “Gross domestic product (GDP) was down by nearly 35 per cent (in 2016), and revenue continued to decline because of falling oil and gas sales and

tax revenues."[52] The nation of Saudi Arabia, to the north of Yemen, has a similar water-scarce environment and population size. "Saudi Arabia is far richer in another resource - oil – and can afford to desalinate seawater and build an economy that does not depend on water-intensive activities like farming."[53] Yemen remains reliant on agriculture and conflict has reduced opportunity for tourism and working abroad to support families at home.

The capital of Sanaa is a microcosm of how population growth and water mismanagement impact the whole of Yemen. "Yemen has one of the highest population growth rates in the world and the capital of Sanaa is growing at an even higher rate due to urbanization.[54] The influx of people to the capital has resulted in water consumption that outpaces groundwater replenishment rates. A 2010 report by forecasted that the Sanaa basin could completely out of water by 2020 if water use remains uncontrolled.[55]

Sanaa is faced with a decision as to how residents will address the loss of water resources. Courses of action to confront Sanaa's water scarcity include; piping water from a desalinization plant on the coast, pumping water from other regional aquifers, relocating the population of Sanaa to other regional aquifers, or staying in place with new efforts to diversify the economy from water intense practices like agriculture. The concern with the population staying in Sanaa is that the reduction of consumption would only prolong the inevitable and increase water procurement costs for the populace. Relocation of the Sanaa residents will potentially cause tensions with existing residents and generate new competition for resources, strain the local environment and tribal tensions over historical homelands. The piping of desalinized water is expensive, but accompanied by water saving measures, may be the most feasible option. "While pumping of water to the elevation of Sana'a (2500 m) is often considered as too expensive, the compared the costs for a pipe line versus the costs of building new

settlements is socially, logistically, financially, politically and internationally, preferable to relocating its population of Sanaa."[56]

Yemen has been plagued by poor water management resulting from the failure of the Yemeni Government to either propose new initiatives or enforce current policies. The lack of strong control over water planning and consumption has resulted in unchecked access to aquifers through wells, poor agricultural practices, and a deteriorating system of water controls and delivery systems. Traditional rain-based methods, such as drip irrigation, have given way to wasteful practices like flood irrigation that drain aquifers.

The Government of Yemen professes to be only entity that can create and maintain wells, but this is contradicted by other traditional law and results in many unaccounted wells with the potential to withdraw disproportionate amounts of groundwater. "According to some interpretations of sharia, which Yemen's constitution specifies as the sole legal framework, a well drilled on privately owned land is the property of the landlord, not of the state."[57] Concerns about the pollution of wells remains valid since many wells are undocumented and not adequately maintained. Pollution seeping into an aquifer could have unattended effects on large portions of a local population depending on the size and flow patterns of the aquifer. The cost benefits of using groundwater wells for irrigation has been associated with the Government of Yemen's subsidizing the cost of diesel.

Diesel is the primary fuel used for the pumps that extract groundwater from wells that are made possible with modern drilling techniques. The cost of diesel remains low enough that many farmers do not feel compelled to adopt more water saving agricultural practices. The government has decreased the diesel subsidy several times over the years, but not enough to spur a significant reduction in groundwater use for irrigation. "For now, the government subsidizes

diesel— the main fuel used to extract groundwater— which accounts for 80 percent of the cost of qat cultivation."[58]

Much of the limited usable agricultural land in Yemen is used to grow qat, a cash crop and mild stimulant.[59] "According to the World Health Organization, up to 90 percent of adult men in Yemen chew qat for three to four hours daily, and women literally sing its praises."[60] Qat has the highest return on investment for Yemeni farmers, thus qat has taken precedence as the crop of choice despite it consuming estimates as great as using 50 percent of all the water used in agriculture.[61] "Not only is the crop (qat) drying the Sana'a Basin, it has displaced over tens of thousands of hectares of vital crops— fruits, vegetables, and coffee— which has sent food prices soaring."[62] The Government of Yemen must continue seeking ways to reduce the growing of qat and incentivize farmers to incorporate crops that are less water-intensive to grow and have actual nutritional value that could benefit portions of Yemen that are in a state of famine. Areas of Yemen that were once habitable and able to support vegetation have become devoid wastelands through desertification, poor water retention, and neglected delivery infrastructure which has led to increased malnutrition in rural groups far from the delivery of foreign aid.

The water infrastructure in Yemen has become antiquated and deteriorated to the point of becoming ineffective in many areas. Dams meant to collect run-off for irrigation are in disrepair to the point water has begun to seep around them. The disrepair of water pipes in areas fortunate enough to have the infrastructure wastes up to 60 percent of the water they are meant to transport.[63]

Yemen experienced one of the worst cases of cholera in modern history in 2017. "The World Health Organization says there have been more than 900,000 suspected cases of cholera in Yemen since late April, many of them children, and that there are expected to be 1 million

cases before the end of the year."[64] The suspected causes of the cholera outbreak include a lack of potable water, damaged sanitation infrastructure, and difficulty in distributing relief aid from foreign governments and relief agencies. A Saudi Arabian-led coalition military blockade of Yemen, in response to a Houthi rebel missile firing at a Saudi airport, compounded difficulties in receiving supplies to combat the outbreak.

Yemen has been ravaged by tribal and religious conflict creating instability throughout the country. The civil war in Yemen began in 2014 as Iran backed Houthi rebels forced the Saudi Arabia-backed government out of power. The proxy war between Iran and Saudi Arabia has killed more than 10,000 Yemenis and displaced 3 million.[65] Water scarcity has been intensified within Yemen as the conflict has resulted in extensive damage to the water infrastructure in Houthi held regions by Saudi-led coalition airstrikes. It has been reported that Saudi-led coalition airstrikes may have targeted a Yemeni desalinization plant. "Satellite imagery of October 28, 2016, confirms significant damage to structures on the premises of the Al-Mocha water desalination plant, though it cannot be established with certainty that this damage is due to the reported airstrike(s) of January 2016, or of the reported airstrikes on October 1, 2016."[66] The lack of water has had devastating effects on the Yemeni peoples' sanitation capacity and food security as people have been either displaced from homes or prevented from growing crops.

The conflict in Yemen has impacted aid to local populations and internally displaced persons. Ports of entry along the coast of Yemen have been restricted by either Saudi-led coalition closures or Houthi rebel actions. Ports facilities and transportation networks have been severely damaged in areas and are causing delays in the distribution of water, food, and medicine to recipients in need. [67] Over 7 million people in Yemen are already in "famine-like conditions", and the number could rise without receiving food and nutritional supplies.[68] Yemen has

instability that is both exasperated by water scarcity and is the direct result of water scarcity in some circumstances. Conflict has prevented a stable Yemeni Government to form and begin the process of stabilization.

Yemen and the instability stemming from internal conflict, supported by external powers, remains a concern to the USG. The USG and Gulf State allies are concerned with Iranian influence associated with the Houthi and the haven Yemen has provided transnational terrorist such as Al-Qaeda. The Red Sea and Gulf of Aden have vital international shipping lanes that support the global economy. The USG has invested significant aid money to help resolve the Yemen crisis in part to protect the nearby sea lanes. During fiscal year 2017 the USG provided $767,534,920 in funding.[69] To achieve stability in Yemen, the USG has targeted critical basic needs and services for support. The U.S. Government supports interventions through USAID and the Bureau for Population Refugees and Migration, including food assistance, medical services, basic household goods, and water treatment supplies to reduce the spread of disease.[70] The U.S. DoD has maintained a naval presence within international waters to assure commerce can continue and to interdict illegal arms transfers to the Houthi rebels and other nefarious actors. A stable government in Yemen is necessary to minimize conflict and better manage the extremely limited water resources.

Assessment of Case Studies

Assessing the case studies of Mali and Yemen will be accomplished by looking at similarities between the two states and then recognizing the significant differences with regards to types of water scarcity, levels of state instability, and the interaction between both phenomena.

Both Mali and Yemen are predominantly agriculturally based; 80 percent and 60 percent of the populations claim agriculture as the primary livelihood respectively. Both states require

irrigation from limited water resources on land becoming increasingly arid thorough natural and man-made causes. Abstraction of aquifers is a major concern in both states as there is not enough precipitation or other surface water to otherwise irrigate crops and meet the needs of sanitation and maintaining livestock. Abstraction occurs throughout Yemen while it is more isolated to the northern and central portions of Mali.

The lack of a fully functioning and credible central government has allowed for internal sectarian, ethnic, and religious conflict in both Mali and Yemen. Weak state economies compounded by water scarcity have resulted in the displacement of some local populaces and increased regional conflict. Competition over water resources resulted in conflict in both case studies, with clear distinction of the water scarcity conflict in Mali falling along ethnic lines in some localities. The lack of government security apparatus has allowed permissive areas to exist that support external nefarious actors, such as Al-Qaeda, and further erode stability by perpetuating violence. The instability in both states has required foreign intervention in support of the respective central governments or direct humanitarian assistance to the populaces by NGOs and foreign government departments. The inability of Mali and Yemen to establish effective governance to reduce conflict and manage declining environmental conditions has been reflected in FSI ratings in recent years. “According to the FSI, Mali and Yemen, along with Libya and Syria, are the four most critically worsened states over the past decade.”[71]

There are significant physical differences between Mali and Yemen, based on water availability. Mali has two major rivers, the Senegal and Niger, which feed wetlands and irrigate crops. Yemen has no rivers and relies heavily upon aquifers and rainfall for freshwater resources. The rivers in Mali present a possibility of regional conflict as current plans are to add an additional large hydroelectric dam. The new dam could further restrict water to downriver

nations and cause deterioration to irrigated lands and the wetlands used for farming, fishing, and pastoral practices. Yemen is a coastal state that has the potential to harness desalinization technology to augment scarce freshwater resources. Mali is a landlocked state and would require significant pipelines to the Atlantic Ocean, at great cost, to incorporate desalinized water into any water resource strategy. Yemen has already invested in desalinization, but conflict has resulted in both a desalinization plant and the water pipeline infrastructure being targeted by aerial bombardment.

Conflict has been prevalent in both Mali and Yemen within recent years. One major difference between the conflicts in each state is related to sovereign borders. Mali has porous borders that can allow for relatively unchecked crossings. Nefarious actors can enter northern portions Mali with relative ease and maintain operations unless driven off by foreign forces supporting the Malian Government. The porous borders of Mali do allow some relief to water scarcity as nomadic herdsmen can gain access to seasonal locales throughout the Sahel. Mali has a very similar FSI rating to the bordering nations. "All of Mali's bordering countries are within one level on the FSI rating scale except for Algeria, which was two levels better."[72] Yemen remains isolated by neighboring Oman and Saudi Arabia to keep the ongoing proxy war between Saudi Arabia and Iran aligned actors within the borders. The isolation of Yemen is indicative of the FSI rating as compared to the two bordering nations. "Yemen's two adjacent countries, Oman and Saudi Arabia, are seven and five rating levels better on the FSI scale."[73] There are no transnational surface water resources that could aid the worsening water scarcity in Yemen, as with the rivers of Mali.

Conclusion

Evidence in the case studies of Mali and Yemen suggests there is a relationship between water scarcity and stability. The resiliency of a state; based on political, social, and economic factors, can determine how much water scarcity impacts stability. A state with strong central governance and adequate resources can at the very least minimize and localize water scarcity issues while supporting the affected populace. Water scarcity issues associated with the Colorado River in the Western U.S. are impacting several states in the region. By comparison to Mali and Yemen, the Colorado River associated water scarcity has not caused famine, disease outbreaks due to a lack of sanitation, or open hostilities amongst the local populace. The U.S. has the resiliency to apply resources to both problem solving the water scarcity issue and supporting affected people.

The cases of Mali and Yemen show water scarcity issues are exacerbated by weak governance. Both Mali and Yemen are resource constrained with regards to water, economy, and the capacity to support the populace without foreign intervention. Existing ethnic, religious, and sectarian strife becomes magnified when basic needs, such as water availability and access, are not being met by a group or several groups. The topics of waterborne disease, such as cholera, and both ethnic and religious tensions are possible future areas of study. Research for this paper has shown that state instability can provide the opportunity for conflict over water resources as security within the populace is low or nonexistent. The research for this paper has not shown water scarcity leading to conflict past the local level, but the potential exists with transnational rivers and nomadic tribesmen. The case study of Yemen has also shown that a state's water resources can be targeted during conflict. The less fragile and more resilient a state is, the more likely that state can better manage water scarcity while minimizing any related potential for

internal and transnational conflict. Continued research, to include case studies for nations in the "warning to stable" spectrum of the FSI rating scale, will facilitate a better understanding of the relationship between water scarcity and state stability.

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