Freshwater management in Libya: a premonition of the global water crisis

Kelly P. Byrnes

University at Albany, State University of New York, mendthesearrows@gmail.com

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FRESHWATER MANAGEMENT IN LIBYA:
A PREMONITION OF THE GLOBAL WATER CRISIS

By

Kelly P. Byrnes

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Abstract

The global supply of freshwater depends on spatial and temporal factors. Because of its nature, there are parts of the world where sufficient amounts are simply not available. With the onset of global climate change and unpredictable politics in some areas, what is referred to as the “global water crisis” will become a cause of unrest throughout the world. Using Libya as an extreme case, this thesis seeks to display the immensely complicated nature of water provision and suggests that the unlikelihood of violent conflict predicted by certain authors, such as Aaron Wolf, needs to be reconsidered. Their faith in the political process is too idealistic. Having no substantial bodies of water and being situated on the Mediterranean Sea, Libya has been left with few freshwater options. Its two main methods for meeting the demand for freshwater are the Great Man-made River Project (GMRP) and desalination plants. Both are multi-faceted and come with a plethora of issues. The complicated nature of these solutions leaves the nation vulnerable to attack and have already been the cause of civil unrest within the country. If violence has already occurred over resources that are not essential to survival, such as oil, it is very likely that violence over water will occur. These problems are a sign of what can be expected in other parts of the world as the global water crisis becomes worse.
Chapter 1

The Global Water Crisis

We are currently witnessing a dramatic oil crisis around the world. Oil is used in many production processes and it is still one of our main sources of fuel. The quest for oil has led to fatal accidents, war, and poverty in regions that are rich in oil fields. These issues will continue until a feasible alternative is found. Fortunately, it is only a matter of time until this happens. Business practices and human behavior will have to adapt to the inevitable loss or extreme shortage of oil out of necessity. These crises have plagued humanity for decades. Experts have been urging for a more sustainable solution for years and we are now starting to see technological innovations that will eventually reduce the need for oil once they receive the necessary support. In a way, the end to these issues is in sight. Thankfully, we know that we have the potential to greatly reduce our oil consumption through the use of renewable technologies and alternative methods. On its own, the resource should not be necessary for our survival, although it does currently seem that way.

In recent years, a phenomenon known as “the water crisis” has been alluded to by scientists around the globe. Due to overpopulation, pollution, changes in land use, and many other factors, freshwater is becoming less available for populations around the world. According to recent projections, the human population is expected to increase by another 3 billion by the middle of the 21st century, most of which will end up living in areas that are poor and have little water. Currently about 1.1 billion people do not even have access to clean drinking water and 2.6 billion do not have adequate sanitation services (Jury and Vaux Jr. 2007). In many ways, the water crisis
is much more serious than the oil crisis. We know we do not need to keep using oil. There are already other ways of harnessing energy that do not require the continuous use of oil (i.e. solar panels, wind farms). Oil is not vital to our survival. On the other hand, water is essential for the survival of just about everything and there is no substitute for it. It is used to manufacture the majority of our products and refine many of the natural resources that we use, including oil. Water is also necessary for the production of food. The water crisis has been deemed so severe that the United Nations has concluded that water scarcity will be the major constraint to increased food production instead of the lack of arable land (UNDP 2007). Drought in major food producing countries such as Australia and parts of the United States and Europe led to major declines in production and is viewed as one of the major contributing factors to the global food crisis of 2008 (Piesse and Thirtle 2009). Others agree that water will likely be “the defining crisis of the twenty-first century” (Chartres and Varma 2010).

The Geographical Perspective

Issues surrounding natural resources will become increasingly serious in the future as the human population continues to follow its disastrous increasing trend. This is why geography is expected to become more important as these issues continue to surface. Being such a broad and “fractured” discipline, as Eric Sheppard puts it (Sheppard 2004), it is sometimes difficult to explain exactly what geography is and how it can apply to a situation. Geography can mean many things to different people but one general concept that all geographers can agree upon is the importance of space, meaning the actual geographic space of the entire planet. Space will become an issue
given the expected rise in population. As the potential space that humans can occupy continues to decrease, our use of natural resources will change. In Peter Gould’s book, “The Geographer at Work,” he emphasizes the importance of space and how events in one part of the world can affect another (Gould 1985). This can be directly tied into the global water crisis. How one country decides to harness and deliver their water to its people will surely have an impact on their water supply. If the water supply is part of a network, it will have an effect on neighboring countries that depend on that same network as well.

The global water crisis is an inherently geographic issue. It is multi-faceted and as we will discuss, it is going to force people to re-think how they manage their relationships with the natural environment. A big factor in how we interact with the natural environment is our location within it. In classical geography, the concept of location was used to describe process, relation, and quantity. Fred Lukermann (1961) believed that geography’s concern with location was no longer a concern in the discipline and it needed to be revisited. Location tells us much of what we need to know. In areas that are already experiencing water issues, location is hugely important. An area’s relative location to major bodies of water determines what can and cannot be done to ensure that people receive ample amounts of water. Natural resource crises will likely revitalize the importance of location in geography and other disciplines as well. It cannot be avoided. Solutions will be relative to the spatial location of each country that experiences water problems. Also, water management in areas that do not have readily available water brings to mind the classical geographic idea of humans versus a difficult environment.

The decisions that will be made concerning water provision will likely come to fruition through the use of politics. John Agnew, former president of the
Association of American Geographers (AAG), gave a presidential address in 2011 in which he supported the use of democratic politics in resolving the water crisis. In this address, he discusses how the term “political” in political geography can be applied to water provision through the use of what he calls six romances that either define or confine the political process. These six romances are as follows (Agnew 2011):

1. The “Platonic” or scientist observer has the requisite expertise and knows exactly what needs to be done. This sometimes contradicts the messiness of politics.
2. Views politics as an inefficient historic alternative to the rationality of markets. In this perspective, water would be commoditized and not seen as a public good.
3. Views politics as a structurally determined process that only benefit those who can “pay to play.”
4. Sees politics in terms of conspiracies in which formal politics is just a mask for conspiratorial interests such as government officials and arms manufacturers.
5. Views the political arising as a conflict of enemies and friends in which a compromise is impossible.
6. Idealist views that see politics as deriving from ethics.

Agnew goes on to explain that these romances all “displace practical politics in the hunt for an overarching abstract principle of the political.” As romantic perspectives, Agnew deems these impractical and believes that they view conflicts in terms of fixed preferences, oppositional individuals and groups, and “zero-sum outcomes.” However, it can be argued that some of these views are not so impractical. The implications of the water crisis are unlike any catastrophe that the world has seen. The resource that all life is based off of will be called into question. As we will see, some of these romances have already presented themselves in actual events that have occurred in Bolivia and Israel/Palestine. Agnew and other authors that he cites appear to put an unusual amount of faith into the political process. They are not convinced that violent conflicts will occur because of the potential and power of political
processes and because water is a resource that we all need to survive. The political process has failed and led to war many times throughout history and it seems unlikely that people will suddenly become civil because a necessary resource is becoming the cause of conflict.

As Rickie Sanders stressed in “The Triumph of Geography” (2008), geography is going to get very interesting in the coming years. Societies will continue to adapt to the changes in the natural environment and the rapid, unexpected consumption of necessary natural resources. The future is going to depend on geography and celebrate what it has to offer in the face of this expected crisis. Deciding upon sustainable solutions will require geographical consideration, both human and physical.

Global Demand and Supply

Since the 1950s, global demand for water has tripled but the freshwater supply has been declining (Gleick 2003). Half a billion people live in areas that are considered water-stressed and according to forecasted increases in population, that number is expected to reach 3 billion by 2025 (Molden et al. 2007). Because of dramatic population growth and rising incomes, the demand for meat and cereal are expected to increase by 56% and 65% respectively (de Fraiture et al. 2007). In order to fulfill these calorie requirements, the demand for water is going to increase dramatically. The data on water supply and demand are disturbing. About 450 million people in 29 countries are now faced with severe water shortages (Serageldin 2001). As much as two-thirds of the world population could be water-stressed by 2025 (Seckler et al. 1999). Aquifers, which supply one-third of the world’s populations, are being
pumped out faster than they can naturally replenish themselves (Shah et al. 2006). In addition, many of the world’s major rivers and lakes are heavily polluted. These issues with supply, demand and pollution are posing key challenges (Hanjra and Qureshi 2010), including:

- Competition between and within territories, transferring water out of agriculture and leaving less for food
- Unequal access to water which will perpetuate poverty and widen the inequalities in access to water for food
- Increase in the incidence of water borne diseases
- Destruction of freshwater ecosystems, impacting ecosystem health and services
- Tension possibly leading to conflict over the use and control of water at national and transnational levels
- Dramatic decrease in agricultural production and crop failure

The Comprehensive Assessment of Water Management in Agriculture (de Fraiture et al. 2007) states that today’s food production requires a consumptive water use of about 6,800,000 m³. About 1,800,000 m³ are supplied by irrigated water. To feed humanity by 2050 on 3000 kcal per person per day (the basis according to the Comprehensive Assessment of Water Management in Agriculture, which takes into account worldwide growth in income and calorie consumption) an additional 5,600,000 m³/year will be required. Taking into account the declining health of our ecosystems and the effects that climate change could have on the water supply, it is going to be incredibly difficult to meet these demands. This will leave a major food gap and it will affect global food security.

We are going to need new methods of harnessing water in many areas around the world just to make sure that everyone gets the water that they need to survive. The sustainability of these solutions will be imperative since the population will continue to grow and climate change will continue as well. In addition, it is important
to take into account the fact that the global supply of freshwater will probably not increase. It needs to be managed in an efficient way so that no one is exploited or getting more than they need. In addition, further studies will be necessary to assess the potential impact of climate change on water resources, poverty, and water productivity to help identify the current adaptation deficit in water resources management (Hanjra and Qureshi 2010).

Water Politics and the Possibility of Violent Conflict

Agnew’s presidential address from 2011 provides some useful insight into the nature of water politics. In one example that he cites by Shaun Cohen and David Frank (Cohen and Frank 2009), four characteristics of water politics examined by Aaron Wolf (1998) have been crucial in negotiating outcomes of disputes over freshwater (Agnew 2011):

1. Water is essential to all life so a single side cannot see themselves as more entitled to all the water provided by a body of water that flows across or on the border of a territory.
2. By using temporal criteria such as the nature of water flow, periods of privileged access can be granted to multiple parties.
3. All parties involved have a vested interest in maintaining the overall quality and multiple uses of the water supply. They can have different rankings of interest that can best be served by negotiating.
4. The focus on the pragmatic water issues needs to be separated from territorial and ideological claims.

These characteristics raise some interesting points and there are strong claims embedded in some of them. In particular, the first characteristic is dubious and some can argue that it is simply false. There have already been cases where one side did feel more entitled to a body of water. In Palestine, the people must deal with stringent
constraints on water that was once theirs. Israel has seized control of the Jordan River and the major aquifers that many people depend on (Barbati 2013). In addition to the population having limited access to water, their land is constantly shrinking as Israel’s population continues to grow. Another case where this occurred was the Mexican War. In the 19th century, the Rio Grande River was disputed. As a result of the U.S. victory, a large portion of the Rio Grande River was considered American territory and was essentially taken from Mexico by force.

There have been other instances of water conflicts in Bolivia. Although this is not a case that occurred between bordering states, this was still an instance where a side seized control of water resources. A significant series of conflicts took place in Cochabamba, the country’s third largest city. This conflict is referred to as the Cochabamba Water War or the Cochabamba Protests of 2000. In April of that year, the war was precipitated when Cochabamba’s municipal water company, SEMAPA, was sold to a transnational consortium that was controlled by the U.S. based Bechtel in exchange for debt relief for the Bolivian government and new World Bank loans to expand the water system. As a consequence, a new law was implemented that enabled Bechtel to control and administer water resources that SEMAPA did not have control of. A large alliance of farmers came together along with factory workers, local water committees, various neighborhood organizations, and students to oppose the privatization of water that was rightfully theirs. These protesters were joined by the militant federation of coca growers. Eventually, Bechtel was forced to void the contract and return control of the water to SEMAPA and withdraw its legal claim against the Bolivian government (Achtenberg 2013). What is apparent in these conflicts is an emerging perspective on “hydro-hegemony,” which Agnew mentions in his address. This concept argues that the outcomes of these conflicts are usually
the results of clear power differentials. In addition, because of the ways in which water is so closely tied with food and agriculture, it is even more subject to disputation (Warner and Zetoun 2008). This concept is especially prevalent in disputes between neighboring territories.

The second and third characteristics are plausible. However, one can simply argue that the fourth characteristic is impossible. Territorial and ideological claims will always be present in any sort of trans-boundary conflict. This is very clear in the Israeli-Palestinian conflict. Wolf’s characteristics might have been observed in some cases of conflict over water and eventual peaceful negotiations. However, it is difficult to believe that just by the very nature of water resources, civil negotiations are likely to take place. Unlike oil and other natural resources that can be manipulated in such a way that others can be denied access to it, the nature of water makes the political process differ. Just because water is essential to all life and manufacturing does not mean that we can always trust countries to turn to politics instead of violence to settle water disputes.

Agnew mentions that Wolf looked through 4,000 years of history and could not find one war over water. He does note that there have been conflicts, but politics was the solution instead of war. In the past, especially thousands of years ago, civilizations have always been forced to settle near bodies of freshwater because it is essential to survive. Once groups of people found it, there were no issues with access. This was well before the population spikes of recent decades. As the human population approaches 7 billion, the situation becomes much more complicated. It is because of this unforeseen influx that sanitation and access have become major problems, especially in poor regions. Just because history tells us that war has not occurred over a resource does not necessarily mean that it is not likely to happen in
the future. Wars have escalated over far less important issues. It is also crucial to note that there have been many wars that started because of disagreements over natural resources. Countless wars have been fought over land (i.e. The French and Indian War, World War I and II) and it is possible that the current wars in the Middle East are being fought over oil. Water will become the next oil, that is, it will become so limited in some regions that violent conflicts will ensue. Unfortunately, what has happened in the past does not necessarily dictate what will happen in the future.

These discussions about food insecurity and water scarcity in academia have led to discourse that comes from the Malthusian belief that there is an imbalance between human population growth and the economic availability of natural resources. According to Malthusian logic, population will continue to grow exponentially while food can only increase linearly. The theory holds that once the limits on necessary natural resources are exceeded, social breakdown and violence will occur. However, technological improvements and greater inputs of capital have dramatically increased labor productivity in agriculture. In general, the neo-Malthusian view is being considered less relevant because humankind has surpassed many resource barriers that were seen as unattainable (Allouche 2011). As a result, the idea of “water wars” has actually become a popular topic in media discourse (Smith 2009) as well as within international organizations (UNDP 2007).

In recent decades, the way in which trans-boundary water is managed has gained increased attention. Since water allocation has a direct impact on the global food system, the likelihood of conflicts over water is imperative to consider in assessing the sustainability, resilience, and stability of global food systems (Allouche 2011). Although the fear surrounding water wars has been inspired by this Malthusian outlook that equates violent conflict with scarcity, specialists tend to agree
now that the issue is not scarcity per se but rather the allocation of water resources between different riparian states (Allouche 2007). The core issue in trans-boundary water relations is each nation’s perception of their estimated water needs. Whether or not this scarcity exists, the perceptions of the amount of available water will shape people’s attitudes towards the environment (Ohlsson 1999).

*Civil Conflict*

At the local and intra-state levels, the link between scarcity and conflict is more complex. At the intra-state level, research on civil wars reveals that countries that suffer from environmental degradation are more likely to experience civil conflict, but that the magnitude of the effects was secondary to political and economic factors. However, there is also evidence that the lack of clean and available freshwater has occasionally led to intense political instability that can lead to violence on an acute local scale. For example, in Africa’s Sahel region, desertification is reducing the availability of land that can be cultivated, which is leading to clashes between farmers and herders (Allouche 2011). In areas that are mostly dry land, drought and famine are constant struggles and conflict has become an accepted reality in these parts of the world. It puts a strain on social and political relations. Due to increased climate variability and the recent increase in natural disasters, the conditions of these areas will likely worsen.

Upon closer examination of conflicts that occur as struggles over natural resources, it seems as if geographical scale and the intensity of conflict are inversely related, but conflicts over water are caused more by the way that water use is governed than by water scarcity (Allouche 2011). The evidence that countries engage
in conflict over water is poor but there is no question that these conflicts are more common at the inter-community, inter-sector, inter-farm, and inter-household levels (Mehta 2005). According to Gleick (2009), the risks of water related conflict can be reduced if: (i) basic human needs for water are met as a way to ensure at least some resemblance of equality if not total justice, (ii) effective operations that keep peace are developed at the United Nations when disputes over resources cannot be dealt with locally, and (iii) diplomats have a better understanding of the connections between conflict and water so that they can implement the tools from other conflict situations to minimize and reduce disputes over water. In addition, the impact of war over water is a serious issue. It is crucial to ensure decent sanitation and safe water for civilians in conflict zones because diseases can have an even worse impact on the area than the actual conflict in terms of mortality. In states that are post-conflict, water sanitation is imperative. Contaminated or unsafe water is directly related to poor health, but the lack of public revenues, investor interest, and government capacity often results in failure to re-establish access to basic infrastructural services (Allouche 2010).

The consensus of the literature regarding water scarcity and resource wars is that these issues are not adequate explanations for war on an international level. But at the national level, water and food insecurity have been important factors in the causes of civil wars. On the local level, food insecurity and water scarcity can possibly lead to violent conflict as well as political instability. Armed conflicts in general tend to create emergency situations with food and water insecurity and have a long-term impact on the societies that experience these conflicts. Allouche (2011) believes that it is unlikely that international resource wars will occur, despite the possibly detrimental effects that climate change will have on these resources. He says it is more likely that these disputes will be settled through means of diplomatic
negotiation and perhaps international trade. He does state that these conflicts are more possible at the intra state level. This is attributed to inequality within countries as well as ethnic and political rivalries. However, given the pattern of conflicts throughout global history and the fact that many of them were fought over natural resources, it is difficult to believe that international wars can be ruled out as a possibility.

*Potential Impacts of Climate Change*

It is tragic for a country to experience civil conflict over a resource that is necessary for life. With the current state of technology having surpassed our highest expectations, one would think that effective management practices can be employed to ensure that everyone is getting the water that they need. This might be a possibility in some areas. The water situation will become incredibly dire for the many countries that already experience frequent droughts and scarce freshwater supplies. The effects of climate change will profoundly impact our water management strategies. We have already witnessed change in stream patterns and significant shrinkage of substantial inland bodies of water, such as Lake Victoria and Lake Chad in Africa, and the Aral Sea in Uzbekistan. The disappearance and changes in these water bodies will only continue. Unfortunately, there are areas that depend on a few or even a single body of water to support all of their needs. Many areas have limited options. The destruction of an inland body of water can spell famine for an entire group of people.

Climate change poses immense challenges to food and water security. In the developing world, water sector adaptations to a changing climate are very costly. Due to immense population growth and different climate change scenarios, irrigated land
will be expected to produce about 70% of the additional food supplies, which places increased pressure on existing water supplies (Döll and Siebert 2002). Although there are a number of theories, there is still uncertainty regarding the specific effects that climate change will have on water resources. This means that there is also uncertainty about how irrigation systems will have to adapt to the changes in climate. This poses complex issues that water institutions and water policies are going to have to address (Hanjra and Qureshi 2010). Climate change scenarios and hydro meteorological records have provided evidence that water resources are very vulnerable to changes in climate and this has strong implications for human security (Allouche 2011).

Currently, about 500 million people worldwide live in countries where water is chronically short and the Intergovernmental Panel on Climate Change (IPCC) predicts that this number will rise as climate change affects surface water levels that depend on glacial melting and rainfall (Bates et al. 2008). The expected heat waves and resulting water shortages, some of which we have already experienced, will create issues with the sanitation of drinking water and disproportionate effects on the poor and vulnerable (Allouche 2011).

Access to Water and the Implications of Wealth Inequality

If climate change creates extreme water scarcity in certain areas as predicted, it is likely that the rich and powerful will have better access to safe and reliable water and those less fortunate could be denied access. Once these cases of inequality begin to happen, they are difficult to stop. It would be shameful for anyone to deny another person access to drinkable water. Unfortunately, these are the types of scenarios that seem likely as water becomes scarce. Even in the United States the wealth inequality
causes certain people to gain access to far more resources than they could ever use while others receive almost nothing. It is difficult to imagine a world where freshwater is hard to come by. Especially in affluent countries, some may not even notice how integral water is to their daily life. It is likely that the availability of freshwater will decline as a result of the expected increase in population and climate change. In the face of this, it will be difficult to devise methods to ensure that everyone is receiving the necessary amount of water.

The idea of wealth inequality coupled with water scarcity and mismanagement due to uncertainty about climate change is frightening. There is already difficulty in ensuring that people in certain countries receive the necessary resources to survive. The water crisis could affect everybody. Although the literature makes educated predictions about what the authors believe is to come, we are not really sure exactly what the water crisis is going to be like. This is the situation that the world will be faced with, especially in the arid regions. A solution could involve an entire re-creation of the extant infrastructure in these areas, which would have serious economic, societal, and political implications. The survival of the people in these regions will rely solely upon their ability to create sustainable, efficient solutions and how they choose to adapt to their changing environment. The best solutions for each country will be exclusive to the specific areas that need them.

The physical geography of the arid and semi arid countries will be the main determinant of how freshwater is collected and delivered in those areas. There are many factors that need to be taken into account to ensure the success of any water management plan. It needs to be affordable, and perhaps one of the best methods of ensuring a system’s affordability is to see to it that at least a portion of the economic benefits are given right back to the people who live in the country of concern rather
than corporations and bureaucrats. If new infrastructure is required to bring people freshwater, members of the local community can be employed to maintain and construct it. Unfortunately, due to constraints on time and resources (as well as lack of data) this study will not include a cost-benefit analysis. Perhaps for future research this can be included at a much later date. For now, we can only make inferences based off of what the available literature has to say about what has happened in the past and what the future might hold.

Moving to the National Level

Upon review of the literature in the field, it appears that many authors are not concerned with the possibility of violent conflicts over water resources. However, there have already been conflicts over water resources. Water patterns and availability are bound to change eventually, the global population is going to continue to rise (although maybe not as dramatically), and our governments and politics are bound to change as well. Timely preparation will be the key to the outcome of this impending crisis. Other issues in the world are at the forefront of the media. But the water crisis is unlike any other crisis the world has ever seen. The very substance that we rely on for all of our manufacturing, refinement processes and for basic survival is going to be called into question. Affluent countries take their access to safe and reliable water for granted. The arid regions that are already faced with freshwater issues are out of sight and out of mind for these parts of the world because the very concept of not having access to the most necessary substance to survival is ludicrous to us. For all we know, even the affluent countries could face serious water issues as
a result of climate change. Perhaps that will be the point in time when these issues will be explored more.

To further delve into the issues brought on by the water crisis, the remainder of this thesis is going to be a case study of Libya, an area where water management has been an issue for decades. The components of this case study will include an assessment of the physical geography of Libya, a brief history of water resources within the country, and overviews of Libya’s two main methods of extracting and harnessing water; the Great Man-made River Project and desalination plants. The point of this case study is to evaluate what Wolf and other experts, such as Agnew, are saying. As mentioned, they view the impending crisis as a serious issue, but Wolf specifically claimed that he could not find violent conflicts that were fought over water and his findings imply that we can rely on politics to settle these issues in the future. He states that there have been many conflicts, but they were all settled using politics instead of full-blown warfare. The basic thesis is that freshwater management is going to become complicated in the future and as a result, the political process will likely fail and violence will occur. Libya will be used as an extreme example to illustrate the already present realities of the water crisis and to show that this reassuring assessment of politics and the water crisis put forth by the aforementioned authors will likely not hold forever.
Chapter 2

Physical Geography of Libya

Hydrographically, Libya is a unique country. However, it is its unique position that makes its water situation such an issue. It is considered one of the driest countries in the world and it is made up of mostly desert (the Libyan Desert). Because of its local climate, there are no substantial sources of freshwater that are readily available for use. According to recent census data, the country’s population is well over 5 million. To ensure that the entire population receives the water that is required for basic survival is a complicated task. Because of its position both in a desert and on the Mediterranean Sea, it is only a matter of time before the country really begins to scramble to meet its demand for water.

Figure 1: Map of Libya

Source: The University of Texas at Austin 2013 (see references)
Figure 2: Libya Demographics and Land Use

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<table>
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<th></th>
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</thead>
<tbody>
<tr>
<td><strong>Area</strong></td>
<td>1,759,540 sq. km</td>
</tr>
<tr>
<td><strong>Population</strong></td>
<td>6,002,347</td>
</tr>
<tr>
<td><strong>Arable land</strong></td>
<td>.99%</td>
</tr>
<tr>
<td><strong>Permanent crops</strong></td>
<td>.19%</td>
</tr>
<tr>
<td><strong>Other</strong></td>
<td>98.82%</td>
</tr>
<tr>
<td><strong>Irrigated land</strong></td>
<td>4,700 sq. km</td>
</tr>
<tr>
<td><strong>Total renewable water resources</strong></td>
<td>700 cubic meters</td>
</tr>
</tbody>
</table>

Source: CIA 2013 (see references)

Figure 3: Population Distribution Map of Libya

Source: BBC 2011 (see references)

Water resource management is complicated in arid and semi-arid regions because of less rainfall and the extreme climatic conditions that augment water loss.
through evaporation. This is typical of Libya, with an average annual rainfall of less than 100 mm and an average evapotranspiration rate of 6.8 mm per day (IMB 1980). This is equivalent to about 2500 mm per year, which is much higher than the average annual rainfall. Because of these limiting factors, developing surface water sources is not a useful option, which puts tremendous pressure on groundwater resources. The majority of the groundwater is used for irrigated agriculture. This represents about 80% of total consumption (Alghariani 2002). A major issue is that while most of the population in Libya is located in a narrow strip along the coast, the majority of the ground water potential is in the southern and central areas of the country beneath the desert. In addition to satisfying the ever increasing demand for agricultural land, these aquifers also have to meet domestic and industrial water demands.

Libya consists of a discontinuous mosaic of more watered and settled territory, embedded in wide expanses of arid and semi-arid land. The areas along the Mediterranean are obviously more productive, but these productive zones are not all linked together. It is broken by expanses where steppe land and semi-desert areas meet the sea. Due to the large expanse of desert in Libya, the country is not considered unified at all in the sense that the major population centers are well isolated from one another. These population centers are generally similar to one another but there are some regional variations, as would be expected. In a structural sense, Libya forms part of what is known as the great African table, which consists of Archaean basements rocks that underlie most of the region. As far as water is concerned, there are no perennial rivers of any kind in Libya with the exception of torrents that flow for a few days each winter. However, there are a good number of large underground caverns that contain a fair amount of water. However, some of
these areas are so deep underground that they are even underneath the Mediterranean Sea (Fisher 1953).

Libya’s Aquifers

Of all the available underground water deposits in Libya, the Murzuq Basin is one of the major water bearing aquifers. Located in the southwest corner of the country, it is bordered by Algeria in the west and Niger and Chad in the south. This basin exists well into the desert and is characterized by very high temperatures during the summer months (average of 39ºC) and low temperatures in the winter (average of 6º C in January) (Shaki and Adeloye 2006). Along with unusually strong winds, the evaporation rate in this area is very high (IMB 1980). As discussed, rainfall is uncommon in most of Libya, including the Murzuq Basin and as a result, the aquifer does not naturally replenish itself. The intrusion of an intense withdrawal regime has resulted in the persistent depression of the piezometric condition within the aquifer (Shaki and Adeloye 2006).

The majority of the agriculture in Libya depends on these underlying aquifers. In some areas, the amount of the groundwater that is withdrawn exceeds the rate of natural replenishment of these aquifers by more than 500% (El Asswad 1995). Libya has five main water regions; the Jifarah Plain and Jabal Nafusah region, the Middle Region, Aljabal Alkhdar region, Fezzan region (which contains the Murzuq Basin), and Alkufrah and Assarir region. These aquifers are incredibly important to the very survival of Libya.
The Jifarah Plain and the Jabal Nafusah region contain over 80% of the irrigated land in the country. The early Cretaceous/Triassic formation contains aquifers with varying degrees of depth and discharge. The Middle Zone is considered a transition zone between the Jifarah Plain in the west, Fezzan and Alharuj in the south, and Aljabal Alkhdar in the east. This area is characterized by Tertiary/Quaternary formations that contain shallow aquifers that are mostly located along the coast. The Aljabal Alkhdar region makes up most of the Benghazi plain and extends to the Egyptian border. The main groundwater reservoir of this area exists in layers of Tertiary limestone formations and is characterized by faults through which water moves to the north towards the Mediterranean Sea and other portions of water.
move to the south. The Fezzan region is in the southwestern part of Libya and groundwater exists in this region in two main aquifers. The Nubian sandstone aquifer in the early Cretaceous/Triassic formations is in the western part of the region. The second aquifer is in Devonian and Cambro-Ordovician formations and is very deep (up to 2000 meters). The Alkufrah and Assarir region is in the southeastern part of Libya. It is characterized by aquifers of Nubian sandstone formation, which is very thick. There are additional aquifers in the north near Assarir in the Tertiary sandstone formation (El Asswad 1995).

Figure 5: Aquifer Characteristics

<table>
<thead>
<tr>
<th>Aquifer</th>
<th>Use (millions of cubic meters / year)</th>
<th>Recharge Rate (millions of cubic meters / year)</th>
<th>Location</th>
</tr>
</thead>
<tbody>
<tr>
<td>Jifarrah Plain &amp; Jabal Nafusah</td>
<td>955</td>
<td>300</td>
<td>NW</td>
</tr>
<tr>
<td>Middle Region</td>
<td>185</td>
<td>150</td>
<td>-</td>
</tr>
<tr>
<td>Aljabal Alkhdar</td>
<td>315</td>
<td>340</td>
<td>NE</td>
</tr>
<tr>
<td>Fezzan Region</td>
<td>400</td>
<td>0*</td>
<td>SW</td>
</tr>
<tr>
<td>Alkufrah and Assarir</td>
<td>320</td>
<td>0*</td>
<td>SE</td>
</tr>
</tbody>
</table>

* The recharge rate of these aquifers is non-existent due to lack of rainfall and high evaporation rates.

Source: El Asswad 1995 (see references)

Data indicate that water consumption at the time in Jifarrah and Jabal Nafusah, the middle region, and Aljabal Alkhdar exceeded the rate of natural recharge by about 1760 million cubic meters per year. It can be assumed that the rate of consumption was at least equal during subsequent years. As a result the groundwater levels have significantly declined. In some areas the decline of the water level has exceeded 70
meters (El Asswad 1995). For those aquifers that are on the Mediterranean coast, there have been issues with seawater intrusion. With the rate of consumption of these aquifers, it is likely that they are near the point of depletion and the overall quality of the water is declining. As the situation worsens it is likely that it will threaten the social life of the country as well as its economy. The continual over-drawing of these aquifers will lead to a disastrous situation.

With issues like seawater intrusion and over-withdrawal of the water from these aquifers, these areas may not be the most reliable for continual water usage.Due to Libya’s arid to semi-arid climate causing the major population centers to be so scattered, transporting this water to those who need it is costly. The physical geography of Libya is a very limiting factor in water management strategies. Although the exact consequences of climate change are unknown, it is likely that the country will become even more arid and with the rate of usage of these aquifers it is nearly impossible that they will ever be greater in quantity than they are now. Water management in Libya is already an incredibly difficult task. It is likely that this strain on resources will cause civil unrest and further complicate the situation. Libya is an area that has already been known to experience dramatic cases of civil unrest. It is important to keep the political climate in mind when delving into water management issues, or any natural resource issues for that matter. The water policies in the area will be the deciding factor in who gets water and how.

Libya’s Oil Resources

Libya has experienced conflict and political unrest over natural resources in the past. An examination of such events can provide insight on what might be expected with
water politics in the future. The effects of such conflicts on the economy and society can be similar in both situations. Oil is the resource that Libya is best known for. Approximately 2 million barrels of oil are extracted from Libya per day, which makes Libya one of the richest countries in Africa (Okechukwu 2012). This has caused more affluent countries to take interest in Libya. Experts warn that oil scarcity increases the likelihood of war. Some of the literature on water politics is often questionable of resource-driven wars. The relationship between violent conflicts and the need for resources is seen as vague by many, but in reality one could trace back the cause of many wars to natural resources. There is not much literature available on conflicts that have occurred over water. So an overview of the nature of oil conflicts will be used to provide insight on the nature of the possibilities of similar conflicts over freshwater sources. We have seen the devastating effects of oil explorations in several regions of the world. As Michael Watts and other authors argue in “The Curse of the Black Gold,” the discovery of oil in the Nigerian Delta has led to government corruption, irresponsible practices of big oil companies, and has caused extreme poverty (Kashi 2008).

There are three main arguments that can be applied here to relate oil resources to conflict (Le Billon 2008). The first is the oil curse argument, which says that oil dependence negatively affects the quality of institutions and also results in economic underperformance over an extended period of time. The second is the oil conflict argument, which posits that oil exploitation, exploration, and consumption increase various forms of violence. This ranges from disputes over rent allocation to environmental and social aspects to international hostilities over oil control and access. The last argument is referred to as the conflict oil argument, which states that oil shapes the tactics, opportunities, and behavior of belligerents by funding their
actions and influencing their relations with external actors as well as local populations. Recent studies suggest that both oil abundance and oil dependence are positively correlated with violent conflict (Fearon 2005). It is also known that oil increases the risk of conflict for weaker states but reduces it for stronger states and medium levels of dependence and abundance trump negative effects of high dependence (Basedau and Lay 2009). In addition, the location of oil and the type of conflict matter. Overlapping conflict and oil areas have been linked to longer governmental conflicts, but not with secessionist ones. The presence of oil in conflict areas increases the fatality rates that result from hostilities and the presence of oil within the country but outside the conflict area also tends to result in increased fatality rates (Lujala 2009).

It is also important to look at how firms who seek to exploit these resources might play a role. As far as oil is concerned, conflicts can directly affect the assets of a company and oil flows as well as its ability to secure financing (Le Billon and Cervantes 2009). In general, war puts governments at a disadvantage in their negotiations with firms. War also can provide advantages for certain firms (Frynas and Mellahi 2003). In addition, war attracts risk-taking companies that are more likely to utilize bribery, military force, and minimal measures of corporate social responsibility. Peace can be interpreted as negative by the financial markets. This is likely due to the fact that war time in any country is coupled with a large increase in the production of necessary goods that are used for war. (Guildolin and La Ferrara 2007). So the geography of wars over oil is not just about scarce oil (as we already mentioned is the nature of resource conflicts). Rather, it is expressed at many different scales with varying degrees of length and violence. As one author puts it,
“the politicizing effects of oil dependence amplify and distort imagined geographies of vulnerability, collusive friendship, enmity, and endangerment” (Sidaway 1998).

*Using Oil as an Analogy*

Obviously we cannot predict the exact nature of the water crisis based on this information about oil conflicts. They are different resources and as such, they will each be treated differently. In addition, if freshwater is ever in a similar situation, it will obviously be occurring at a different time and there is no telling what those political climates might be like. However, it is likely that water conflicts will be more serious based on the fact that water is a necessary resource and oil is not. Although oil is used for the production of energy and manufacturing, many scientists have already come up with alternatives to oil. Since the situation surrounding oil is becoming increasingly dire and also since we may simply come to a point where there is no oil left, it could very well cease to be used at all at some point in the future. But there is no substitute for water.

Using Le Billon’s three main arguments regarding oil resources and conflict, it will be useful to slightly alter them to speculate how these might relate to water resources. The first, the *oil curse argument* becomes the *water curse argument*, and it would state that water dependence negatively affects the quality of institutions and has negative impacts on economic performance. This one is slightly problematic because every country will depend on water no matter what. However, there will be dependencies of varying degrees that will be directly linked with how high the population is, what the country of concern’s manufacturing is like, and how large their agricultural sector is. This argument is slightly applicable. The second one, the
*oil conflict argument* becomes the *water conflict argument*, and it would state that water exploitation, exploration, and consumption increase various forms of violence. These can range from environmental and social issues as well as hostilities over control and access of reliable freshwater. This one is applicable, especially if powerful countries exploit weaker countries out of what they might think is a necessity. These weaker countries will have no choice but to defend their resources, considering their lives will depend on it. The last argument, the *conflict oil argument* becomes the *conflict water argument*, and it would state that water shapes the opportunities, tactics, and behavior of belligerents by funding their actions and influencing their relationships with local populations and outside actors. This one is applicable as well. If a country is experiencing a local freshwater crisis or if they have an abundance of it, it will directly influence its relations with other countries, especially bordering ones.

This is clearly intellectual speculation at best. However, these are safe assumptions to make. If water becomes as much of a commodity as experts are predicting, it seems impossible that the struggle for each country to seize control of it will be mild compared to what we are currently seeing with the struggle for oil. As a country whose freshwater situation is already complex, it is likely that Libya will have to evaluate their civil and foreign relationships. The water underneath the desert is going to run out eventually and the people of Libya cannot wait for the aquifers to naturally replenish themselves. In order to have a reliable freshwater supply, Libya has been faced with two main options that need to be used in conjunction with each other; draw from the aquifers and desalinate water from the Mediterranean Sea. These both have strong implications for the country as a whole on many levels. It is important to note that these two methods were supported by the Libyan government.
Although the country was under Italian rule for decades, the water management strategies present during that time did not leave any legacy on what is currently in place. Libya declared its independence from Italy before the aquifers beneath the desert were even discovered.

We now know what the nature of the aquifers in Libya is. The water, while finite, is there. But as discussed, the major population centers are fairly isolated from one another. In addition to the already present issue of drawing the water from the ground, the water needs to be transported long distances across desolate arid lands. Any method that could be used in this situation would be one that would require constant maintenance and large amounts of money in order to maintain. In the next section, we will discuss the infrastructure that Libya uses in order to deliver its freshwater to these main population centers that are located along the coast and are generally far away from the precious aquifers beneath the desert. This will include its construction, history, and cost.
Chapter 3

Considerations for Water Taken From Aquifers

To take water from the aquifers in the desert to the population centers requires an infrastructure that is both intrusive to the environment and incredibly complicated to maintain. But Libya does not have many options for meeting its demand for freshwater. An extensive pipeline known as the Great Man-made River Project (GMRP) is Libya’s method of transporting the water from the aquifers across its vast desert. It has been in the process of being built for years and the final product is not expected to be finished for years. Due to delays in the process that will be discussed in this chapter, the GMRP is still under intense construction. It is the main source of freshwater for the people of Libya and as such, is hugely important to their survival. Although the aquifers are finite, they are substantial collectively. While it is a practical solution for delivering water to the people, it is the result of exploitation and exploration of water resources (our adaptation of Le Billon’s oil conflict argument) and as a result, its very nature increases the likelihood of conflicts related to water.

The GMRP is a prime example of the delicate and complicated nature of water politics and potential conflicts. The very fact that it exists, while it certainly is crucial for Libya’s survival, can attract conflict on its own. It is a massive infrastructure, which makes it incredibly vulnerable. It also makes the country as a whole vulnerable since the destruction of their water supply would be as simple as attacking the GMRP. As we will see, the planning and construction for the project so far was no small task. It will be important to keep in mind Aaron Wolf’s aforementioned characteristics of water conflicts that were settled and how they may or may not apply to the GMRP.
Although water sciences (hydrology in particular) are so developed, groundwater resources are still considered as an unseen resource compared to surface water in two main ways (Elhassadi 2007):

- Quality – the change that can occur in quality is usually expected and rarely predicted
- Quantity – the complicated nature of the engineering and underground reservoirs prevents accurate estimation of the quantity as well as accessibility of the aquifer

Another major issue for the aquifers in Libya is the intrusion of seawater, which deteriorates the water quality within these aquifers. In order to manage different water resources as well as the treatment of water for specific uses would mean the necessary evaluation and utilization of these water resources. Water from aquifers is a natural but non-renewable resource and just like any other water resource, it needs to be carefully managed and utilized. What is even more important for these underground sources is that its consumption needs to be managed using sound scientific practices.

The Great Man-made River Project – Gaddafi’s Vision

The GMRP was considered a political move for Muammar Gaddafi. After he took power in a nonviolent coup from King Idris during the revolution in 1969, the government nationalized the oil companies and invested the revenues that were made from the oil to take control of the freshwater supply by putting in hundreds of wells. Farms were established in the south to persuade people to move to the desert but people much preferred to live on the coast instead. This unanticipated outcome catalyzed the decision to bring the water to the people. After the Libyan government
completed feasibility studies to ensure that this would be a possibility, the Great Man-made River Authority (GMRA) was set up in 1983 to handle the project. The project is completely funded by the government and although it took place in several separate phases, these phases will ideally integrate into one cohesive unit. Since Gaddafi and the Libyan government agreed that water is a basic human right, there has not been any charge to the people and no loans were needed to cover the total cost of the project (Mathaba 2013).

The aquifers underneath the Libyan Desert were discovered in the 1950s during the process of oil exploration. In the 1970s, these newfound aquifers were partially developed and reached a production level of about 500,000 cubic meters per day (cm/d) and mainly supplied water for agriculture. Studies were done by the Libyan government to figure out the best method of utilizing the fossilized water. It was officially decided that it would not be cost effective to grow crops in the southern part of the country to accommodate for the location of the majority of the aquifers. Instead, it was decided that a network of pipelines were to be built to transfer the water to the more fertile areas of the country that have already developed coastal plains (The Great Man-made River Project 2011). Thus, the original idea for the GMRP was conceptualized. The first official plans were formulated in the 1980’s by Brown and Root, an engineering contractor from the United Kingdom (now located in the United States and part of KBR and Price Brothers).
The plans that were drawn up by the consultants at Brown and Root called for the massive water pipeline network to be built in phases. The plan envisioned a total of 1,350 production wells to be spread across four basins, all of which would be connected to the coast by 600,000 sections of pre-stressed concrete cylinder pipes (PCCP) that would be underground in order to avoid evaporation. The plan called for 4,000 km of pipeline to be laid. The first of the well fields to be developed were planned at Tazerbo and Sarir, in the east and southeast of the country respectively. At these two locations, a total of 284 wells were to be drilled and ultimately pump 2 million cm/d. After these two locations, the development of three well fields on the
Hassouna basin was to take place and aimed to deliver 2.5 million cm/d from 586 wells in the northeast, east, and west Jabal Hassouna fields. It was thought that these first two phases would be the most productive so they were considered priorities. The development of one well field at Kufra was planned and would contribute 1.68 million cm/d. It was decided that this would be followed by new well fields at Jaghboub and Ghadames, which would take more water from the Sirte and Hassouna basins (The Great Man-made River Project 2011).

Construction in Phases

(All information in this section is taken from the MEED document unless otherwise stated).

Each of the well fields was to be connected to distribution networks and storage reservoirs for agricultural and domestic purposes through the use of pipelines that were four meters in diameter. The Kufra, Sarir and Tazerbo well fields were to be connected to the network in the east and would transport water to another holding reservoir at Ajdabiya and then on to two larger reservoirs, called Omar Mukhtar and Al-Gardabiya. The Jaghboub system, which was separate, was made to service Tobruk and the areas surrounding it. The Hassouna project in the west was to deliver water to Tripoli, the capital, as well as Tarhouna and the Ghadames pipeline would serve Azzawiya and Zuara on the coast. Eventually, the Kufra-Sarir-Tazerbo-Sirte-Benghazi system would be linked through the pipeline to the Hassouna-Tripoli network, which would create a nationwide system. Overall, the GMRP called for the construction of five large storage reservoirs that had a total holding capacity of 55 million cubic meters. One of the major components of the project was the
construction of the two PCCP manufacturing plants at Brega and Sarir. Each of these was to be provided with water from specially drilled well fields. In addition, a 90 MW power plant was to provide energy at the Sarir plant and the drilling operations that were taking place nearby. Originally, the plan was to occur in three phases but the plan was revised and a fourth phase was added that would include the development of the Kufra field, the Sirte-Tripoli pipeline and the Kufra-Sarir pipeline. In addition, the GMRA thought about including a fifth phase that would connect the Hassouna-Jifarah portion of the project to the well field at Sarir Qattusah in the west. This would have contributed an additional 500,000 cm/d to the GMRP, but this phase was not implemented.

Phase 1 of the GMRP covered the building of the Tazerbo-Sarir-Sirte-Benghazi system (also known as the SS/TB project). This phase consists of multiple distinct parts. The Tazerbo well field connects to a large connection tank, which is connected to the first major pipeline network, which transports water to Sarir. In Sarir there are two additional collections tanks and the separate Sarir collection system is linked to the main pipeline. From this section, two large pipes (4 meters in diameter) extend 380 km north to the Ajdabiya reservoir. Then these two pipelines extend east and west to Benghazi and Sirte. Then they meet reservoirs in these locations that are built to stock water in the likely event of a drought. In addition to the pipelines, the contractor built a 1,500 km road used to transport equipment used to maintain the pipelines. This phase was inaugurated in 1993 but it was not completed until 1996-1997.

Phase 2 started in 1986. It included 2,115 km of pipeline to carry 2.5 million cm/d of water from the northeast, east, and west of the Jabal Hassouna well fields to Tarhouna on the Jifarah Plain and then to Tripoli. Associated pumping stations were
included as well as regulating tanks and 2,155 km of road. The city of Tripoli reviewed the project in 1991 when wells that were included in phase 1 started to collapse. The coastal aquifers were being depleted faster than expected and the demand for water in urban areas kept increasing. Following review, Tripoli made the decision to expand the scope of phase 2 by adding a 380 km pipeline to link the Hassouna field with Tripoli and Tarhouna. This increased the cost of the overall project by $760 million. Originally, phase 2 was only supposed to cover the construction of a long central pipeline to connect the well field with Tripoli. The eastern line integrated the system into the phase 1 pipeline using a second pipeline to link it with the facilities in Sirte. In 1997, Tripoli decided to competitively tender the phase and divide the work into seven different parts. It was around this time that political instability in Libya and a drop in oil prices forced the project to be put on hold until 1999. Disagreements between Tripoli and the sub-contractor having to do with finances and work scope led to a French company called Vinci Construction to finish the project by building pumping stations in Assadada, Al-Gardabiya and Wadi Wishkah.

Phase 3 was originally contracted to a Japanese company called Nippon Koei and the UK’s Halcrow in 2001. This had a reduced scope compared to the first two phases of the project. Phase 3 covered the construction of the pumping stations at the Kufra well field and a 380 km pipeline that linked the field with the Sarir/Tazerbo network. It also included a 140,000 cubic meter regulating tank, roads, and stations used to manage the flow of the water. The contract for phase 3 expired in 2009 and it required that new studies of the field be carried out. In 2005, a Turkish company (Tekfen) was given a contract to build a pipeline to link Kufra with Sarir and in 2010,
a Canadian company was given a contract to design and build the Kufra well field system by 2015.

The company Al-Nahr was given the contract for phase 4 of the project in 2004 which covered construction of production facilities, drilling, and the installation of pipeline systems for the Ghadames-Azzawiya-Zuara and Jaghboub-Tobruk systems. The next year, Al-Nahr gave a design and project management subcontract to Brown and Root. Because of the civil war, the Ghadames-Azzawiya-Zuara section was delayed past its scheduled completion in 2011. (In addition to these four phases, there is a fifth phase underway that it not included in the MEED document).

Figure 7: Summary of Phases 1 – 4

<table>
<thead>
<tr>
<th>Major construction contracts awarded on the Great Man-made River проект</th>
<th>Contract type</th>
<th>Value ($m)</th>
<th>Contractor</th>
</tr>
</thead>
<tbody>
<tr>
<td>Phase 1</td>
<td>Sanar-Sarbu/Tazurto-Bengheil system</td>
<td>Main construction contract</td>
<td>3.800</td>
</tr>
<tr>
<td></td>
<td>Reservoirs</td>
<td>Construction subcontract</td>
<td>na</td>
</tr>
<tr>
<td></td>
<td>Tazurto/Sanar wellfield</td>
<td>Drilling</td>
<td>na</td>
</tr>
<tr>
<td>Phase 2</td>
<td>Hassuouna-Tripoli-Tarhouna/Azadad system</td>
<td>Main construction contract</td>
<td>8,100</td>
</tr>
<tr>
<td></td>
<td>Hassuouna-Tarhouna system</td>
<td>Main construction contract</td>
<td>760</td>
</tr>
<tr>
<td></td>
<td>Hassuouna wellfield</td>
<td>Drilling</td>
<td>260</td>
</tr>
<tr>
<td>Phase 3</td>
<td>Al-Gardabiya/Azadad pumping stations</td>
<td>Main construction contract</td>
<td>410</td>
</tr>
<tr>
<td></td>
<td>Al-Gardabiya/Azadad pipeline</td>
<td>Main construction contract</td>
<td>na</td>
</tr>
<tr>
<td></td>
<td>Kufra wellfield system</td>
<td>Main construction contract</td>
<td>450</td>
</tr>
<tr>
<td></td>
<td>Kufra-Tazurto/Sanar pipeline system</td>
<td>Main construction contract</td>
<td>500</td>
</tr>
<tr>
<td></td>
<td>Sanar pipe production plant</td>
<td>Revamp and operation</td>
<td>1,100</td>
</tr>
<tr>
<td>Phase 4</td>
<td>Ghadames/Azzawa/Azzawiya system</td>
<td>Design, construction, operation of Ghadames-Azzawa/Azzawiya system; Jaghboub-Tobruk system</td>
<td>960</td>
</tr>
</tbody>
</table>

na=Not available. Source: MEED Insight

Planned water usage for the first three phases of the GMR project (cm/d)

<table>
<thead>
<tr>
<th>Phase</th>
<th>Municipal</th>
<th>Agricultural</th>
<th>Industrial</th>
<th>Total</th>
</tr>
</thead>
<tbody>
<tr>
<td>Phase 1</td>
<td>410,170</td>
<td>1,506,000</td>
<td>83,800</td>
<td>2,000,000</td>
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<tr>
<td>Phase 2</td>
<td>1,510,090</td>
<td>1,175,600</td>
<td>6,200</td>
<td>2,500,000</td>
</tr>
<tr>
<td>Phase 3</td>
<td>253,000</td>
<td>1,427,000</td>
<td>0</td>
<td>1,680,000</td>
</tr>
</tbody>
</table>

Source: The Great Man-made River Project 2011 (see references)
With all phases built and operational as planned, the GMRP will have the capacity to transport 6.5 million cubic meters of water per day. Strong advocates of the project have stated that due to the enormous size of the aquifers, the GMRP could supply water to the people of Libya for thousands of years. However, since the aquifers exist underneath a desert, natural replenishment occurs very slowly so it is likely that these aquifers will be depleted eventually. Agriculture has always been the main beneficiary of the GMRP. Since it became operational, Tripoli set a target for at least 80% of GMRP water to be used for agriculture by irrigating approximately 160,000 hectares of land. But due to the decline in water production from the coastal aquifer systems in northern Libya and the slow pace of development in the nation’s desalination network, the target was lowered to 66% before the civil war.

The GMRP was always seen as a highly political project for Gaddafi, who referred to it as “the eighth wonder of the world.” It is very unlikely that the total completion of the project will be abandoned because of the massive amount of money that has been put into it over the years and because of its massive contribution to the national water supply. However, it is likely that the GMRP will not be sufficient if future investments are not made. Therefore, additional production strategies will have to be implemented if it is denied further funds. In addition to finances, the GMRP is drawing from a finite supply of water. As far as the future is concerned, the GMRP alone will not be sufficient in providing water to the entire country forever. Other strategies need to be explored and possibly used in conjunction with the GMRP. As we will discuss in the next chapter, desalination plants are being used for this very purpose.
Conflict Surrounding the GMRP

During the NATO-led war against Libya, the GMRP sustained some damage. One of the more notable occurrences was the Brega PCCP plant, which was hit by NATO air strikes in July 2011. It was said to be targeted at the time because it was under control by Gaddafi loyalists and was also home to numerous rocket launchers. Immediately after the civil war, Tripoli’s commitment to completion of contracts regarding the GMRP was questionable. When the war started, the first three phases of the project were completed. At the time, many foreign workers were still working on completing the remaining phases of the project, but violence caused most of them to return home. In July 2011, NATO also bombed the factory that was used for making the pipes in addition to the GMRP water supply pipeline near Brega. These actions were justified by claiming that it was used as a “military storage facility” and that rockets were being launched from that location. As a result of these bombings, six of the facility’s security guards were killed and 70% of the population who depended on the piped supply for irrigation and personal use had no access to water (Mathaba 2013). The construction of the last two phases of the GMRP was supposed to take place over the course of the next 20 or so years but NATO’s war has put the completion of these phases into jeopardy.

Information regarding these events is difficult to get in the United States, since it is a part of NATO. The events that took place in Libya around this time were covered by the media but unclear. However, according to Mathaba’s article, there were direct attacks on Libya’s water supply, or rather, the infrastructure that millions of citizens depend on for access to their water supply. When NATO gave details about the attack, they referred to the facility that they targeted as a “military storage
facility” (Human Rights Investigations 2011). This was a direct human rights violation without any peaceful political negotiations. The fact that water is a necessity (Wolf’s first of 4 characteristics of disputes over freshwater) clearly did not factor into NATO’s decision to attack the facility. Although this was not an example of a conflict between two sides over a body of water, it still shows how the GMRP makes Libya more vulnerable to attack.

After NATO bombed the GMRP facilities, half of the population was without running water for a month. As a result, the people of Libya had no choice but to fully depend on, and in a sense, become enslaved to, the NATO installed government (Mathaba 2013). Whether or not there were military operations taking place in the GMRP facilities that were hit, a terrible crime was still committed that denied people access to reliable water. It is difficult to decide what to believe in the face of current affairs when the media in countries included in the NATO treaty present the story a certain way. The fact that parts of the GMRP were directly attacked was not presented in these reports. The western world’s perception of Libya is likely skewed and inaccurate.

Theoretical Cost Analysis

Given the aforementioned conditions of the GMRP, hard economic data is impossible to obtain and it is difficult to analyze the total costs of the project and assess it from an economic standpoint. With these circumstances in mind, we will attempt a theoretical approach to gain a better understanding of the economic aspects of the GMRP. For this sort of analysis, the following considerations should be understood (Elhassadi 2007):
Technical considerations to define the design criteria that is used in performing the conceptual design of feed and product water quality requirements, size and capacity of the project, output and input site specific designs, etc.

Economic considerations to decide the cost criteria that will establish the necessary parameters that are used to calculate the capital and operating costs.

Environmental considerations to better assess the impact that the project will have and to ensure that the project is safe.

Human development considerations to address the public issue to create positive awareness and achieve the public’s interest aim for better development.

Based on a theoretical study that considers the influence of interest rates and capital costs, Elhassadi concludes that GMRP water is lower in price than desalinated water and it is also the most competitive with other alternatives. The author states that this result occurs at the expense of neglecting the evaluation of other factors, including:

- GMRP water is approaching alternative methods as the project ages.
- The quality of GMRP water is deteriorating since it is being extracted excessively and will undoubtedly be polluted.
- GMRP problem shooting for such a massive engineering project such as this is anticipated.

Another study done by Gijsbers and Loucks concludes that expanding the GMRP would be more cost-effective than adding capacity to desalination plants. Desalination cost estimates for Libya ranged from .9-1.3 US$ (Alain 1996). GMRP costs were also examined in this study and range from about .3-.05 Libyan Dinar per cubic meters for most demand scenarios and device configurations, depending on the total amount of water that is delivered to the various demand sites. The exchange rates and price per cubic meter of water at the time of this study can be seen in the following table (Ibid):
Desalination Cost Estimates for Libya

<table>
<thead>
<tr>
<th>Cost Estimate</th>
<th>Description</th>
<th>Cost (US$ / cubic meter)</th>
</tr>
</thead>
<tbody>
<tr>
<td>US $ (Alain 1996; Bushnak 1996a,b)</td>
<td></td>
<td>0.9 – 1.3 US$</td>
</tr>
<tr>
<td>LD via official exchange rate (1 LD ~ 3 US$)</td>
<td></td>
<td>0.3 – 0.4 LD</td>
</tr>
<tr>
<td>LD via official exchange rate (3 LD ~ 1 US$)</td>
<td></td>
<td>2.7 – 3.9 LC</td>
</tr>
<tr>
<td>GMRP cost estimates</td>
<td></td>
<td></td>
</tr>
<tr>
<td>LD (Loucks and Pallas 1997)</td>
<td></td>
<td>0.05 – 0.30 LD</td>
</tr>
</tbody>
</table>

Source: Alain 1996 (see references)

Gijsbers and Loucks go on to explain that only under optimistic desalination costs and a good exchange rate between US and Libyan currency may desalination be less expensive than expanding the capacity of the GMRP but only for a limited range of demands (i.e. at points where new fixed investments in GMRP capacity would be necessary to meet the increasing demands). Beyond this range, the GMRP appears cost effective. As we will explain in the next chapter, desalination plants are used to meet the additional demands that the GMRP cannot meet on its own. So in general, to produce a cubic meter of desalinated water is more expensive than the savings result from a reduction of one cubic meter of GMRP water from the aquifers. However, the arguments for desalination to enhance the reliability of the system appear to be stronger than those based on the costs present at the time of this study (Gijsbers and Loucks 1998).

Concluding Thoughts for Use of the GMRP

Unfortunately, it is unknown what the economic impact of a fully functional system would be so it is difficult to make a recommendation and base it on specific economic costs and benefits. However, it can be concluded that expansion and completion of the GMRP would be ideal for the people of Libya. Projections indicate that the
demand for freshwater will continue to rise dramatically as time passes. Again, a finite supply of water alone is not a sustainable option. It just creates another issue that will need to be addressed in the future once these aquifers start to run dry. But for now, while the water is semi-reliable, the GMRP is serving its basic function.

The political issues surrounding the GMRP may be issues that need to be handled with desalination plants as well. But NATO’s actions in Libya create an unfortunate forecast for events that could take place in the future. As we discussed in the first chapter, conflicts over water seem to occur more often over issues of water management rather than water scarcity, and the GMRP is a proposed solution to both of these issues. If outside entities insist on taking control of such an infrastructure, it is very likely that violent conflict will continue to take place in Libya. Another issue to consider is the fact that Libya is one country in a vast desert. If the global water crisis continues as forecasted (meaning water will become increasingly scarce) it is likely that other countries might attempt to move in and take control of an already functional system that has access to freshwater. The countries surrounding Libya are water scarce countries, but now that Libya has successfully tapped into these immense aquifers, it is likely that it will continue to attract the attention of neighboring countries in the future. These issues are unfortunately impossible to predict and they will be virtually unavoidable for a structure such as the GMRP. Because of its magnitude, it is a difficult entity to protect. Due to water’s classification as a fixed local resource (Agnew 2011) and the incredibly vulnerable GMRP, a government or other agency can seize control of water that is locally available and use it to exercise power over the people of Libya. Perhaps this is what was intended when NATO attacked the GMRP.
The GMRP is a necessary tactic to ensure the survival of Libya. It is a technological masterpiece that is ahead of its time. Its intricate nature and expansive infrastructure make it incredibly difficult to manage and defend. These are the types of solutions that will likely be necessary in areas of similar climate and physical geography. However, the harnessing and delivering of freshwater in Libya becomes more complicated. The GMRP is still not completed and cannot meet the demands of the entire country. To compensate, Libya utilizes desalination plants. In the next section, we will discuss the presence and future possibilities of these plants. They draw from a supply of water that is virtually unlimited, although the technical feasibility of using such technology on a nation-wide scale will be called into question.
Chapter 4

History of Desalination Plants in Libya

The GMRP offers direct access to vast amounts of freshwater. Although it is extensive and has proven to be vulnerable to certain threats, it is serving its purpose to the people of Libya. However, due to the predicted political climate and the threat of the global water crisis, the GMRP cannot be used on its own. The increasing demand coupled with the fact that it draws water from finite supplies means that it is not sustainable. Before the GMRP was even a thought, Libya was already using desalination plants to harness freshwater. It is important that these two methods be effectively integrated into the country’s water management policy because they will become increasingly important in the future. The population will grow, the water supply beneath the desert will continue to diminish and the GMRP is not complete. Desalination can and will make up for the extra demand that the GMRP cannot meet. This is not to say that the GMRP is an ineffective solution. It is integral to ensuring freshwater is provided to everyone. It does need to be managed effectively with desalination plants to ensure that an ample freshwater supply is available for all necessary purposes.

Many experts consider desalination to be one of the most promising water supply techniques for coastal countries that have limited resources. Libya turned to desalination as a supplemental water resource in the 1960s. In the Mediterranean region, Libya is one of the largest users of both thermal and membrane desalination technologies. This is likely due to the location of the population centers on the coast. This means that the water has much less distance to travel to the major cities. The
first desalination plant in Libya was a thermal system. It was installed in the 1960s in the city of Sirt for the industrial needs of the ASO Oil Company. In a thermal desalination system, the seawater is transformed into steam and then condensed to produce freshwater. Numerous thermal techniques such as multi-stage flash, multi-effect distillation, and vapor compression are used to operate on the principle of boiling water at low temperatures by reducing the vapor pressure. Thermal desalination also requires a pre-treatment process where suspended solids are removed from the incoming seawater and necessary chemicals are added (Wheida and Verhoeven 2004).

The use of desalination plants has increased dramatically since it began in the 1960s. There were over 400 plants in Libya by 1996. The largest installed capacities of over 400 cubic meters per day are provided by 92 multi-stage flash (MSF) plants located along the coast. The capacities of these plants increased steadily since they became operational. The desalinated water from these plants is mainly used for industrial and municipal purposes. These account for 29% and 58% of the total installed capacity respectively. Only 3% is dedicated to other uses such as irrigation, tourism, and power generation (Abufayed and El-Ghuel 2001).

Issues with Desalination

As can be expected with any sort of massive infrastructure of this sort, desalination plants have certain difficulties associated with them. The following issues are applicable to their use in Libya (Wheida and Verhoeven 2004):

- Lack of a central authority that specializes in seawater desalination has resulted in a major dependence on outside contractors from other countries for
design, operation, construction, maintenance, and operation of the plants. It is possible that these foreign contractors have different goals from the local authority in completing their work.

- No exchange of information and poor documentation causes repeated mistakes to be made in the design and construction of these plants.
- Uncertainty of future strategies coupled with the lack of training programs for the operation of different kinds of technologies has a major negative impact on the efficiency of production.
- The locations of the sites need to be chosen so that they can avoid long-shore currents, marine weeds, and large temperature differences. These can all cause major damage to the plants.
- Competitive contractors have offered unreliable equipment at low prices and there is a lack of laboratories, which are important in ensuring the optimum production quality of the desalination plants.
- Pushing the capacity of some of the plants beyond the average demands can cause either a high production price or discontinuities in the production process.
- High production costs can occur as a result of choosing technology that is not suitable.
- The shortage of spare parts and the delay in the supply of materials have a negative impact on the production process in many stations.
- The negligence of the importance of non-conventional water resources and its relationship to the more conventional resources in balancing the water situation in Libya has caused a delay in the development of desalination techniques.

The authors note that these issues mostly occur in the smaller desalination plants. The larger plants can still be run effectively by local engineers. They also stress that it is imperative that people who have the proper education and experience are put in charge to run these plants as that will substantially improve their efficiency.

A major concern with these desalination plants is cost. There are different factors that affect the cost and call for a standard format to compare and assess desalination technologies for conditions that are specific to each site. In addition, there are several different methods that are used to desalinize water, each of which imposes different costs. As discussed, MSF is used the most (around 62%). Multi effect desalination and vapor compression (MED and VC) account for about 9.2% of the total installed capacity. Reverse osmosis (RO) is about 18.6% and electrodialysis (ED) accounts for around 9.2% (Ashour and Ghurbal 2004). With good data, a more
in-depth analysis could be used here but unfortunately there are none available. However, we can speak to some issues that were mentioned by Ashour and Ghurbal in their brief study. They discuss the main factors affecting cost of the desalination plants. The main drivers of high costs are capital investment and utilization factors. The specific costs are not relevant to our discussion, but they do make recommendations for improving the economics of desalination and in effect, they reduce production costs. Site selection is identified as a key factor. It is important for the plants to be located in an area that can enable it to be easily connected to the main water distribution networks. This is strongly reminiscent of classical location theory, also known as the Weber Model. Classical location theory is concerned with locating industrial areas in such a way that transportation costs are minimized. The other recommendations that are given seem obvious, such as increasing local participation, reducing labor costs by employing highly skilled operators and using preventative maintenance to reduce the cost of spare parts.

*Environmental Impact*

The process of desalination is very intrusive to the environment. This is an important consideration for the planning process, especially if the network of desalination plants on the coast is going to continue to expand as it has since the 1960s. Although the method as a whole is incredibly helpful in ensuring that freshwater demands are met throughout the country, the overall health of the environment cannot be compromised. One of the most important aspects of geography is the way in which humans interact with the surrounding environment. This will become increasingly more important as vital natural resources are depleted. To ensure longevity of the systems that are used
to harness these vital resources, sustainable and effective systems need to exist in harmony with the environment in order to be considered sustainable solutions. Management of coastal areas is complicated. It is multi-disciplinary and includes multiple dimensions including technology, science, and the humanities. There are social, ecological, legal, international, and economic factors to consider (Cicin-Sain and Knecht 1998). The environmental impacts are as follows (Liu, Sheu, and Tseng 2013):

1. **Air**: The direct air pollution that occurs as a result of the operations of a desalination plant is typically not significant. But due to the fact that the desalination process being so energy intensive, the energy requirements can cause indirect air pollution from additional consumption of fossil fuels.

2. **Oceanography**: Pumping and discharging in coastal water over a substantial period of time can have an impact on ocean currents. In general, a desalination plant might have a limited impact on erosion and deposition of the coastline. The pipelines and structures that are present underwater can also impact ocean currents.

3. **Hydrology and water quality**: Coastal development can increase the amount of particulates in the seawater and can significantly impact marine organisms. The main source of pollution comes from the discharge of brine and chemical substances that increases the salinity. These pollutants need to be investigated and an allowable maximum needs to be established.

4. **Topography and geology**: The seabed can be disturbed by complicated oceanography events like coastal currents and tides. After the pipes are put into place, the disturbance of the tide can cause erosion and deposition and can even result in an uneven subsidence around the pipeline. This can disturb underwater habitats. The geologic characteristics of a potential site need to be assessed and fault zones should always be avoided.

5. **Plant structure**: Impacts of the structure of the desalination plant include noise and vibration from construction and routine operation. This can disturb nearby organisms, causing them to move, leave their shelters, and cause the separation of groups.

Once a desalination plant is put in place, the physical environment of the area cannot return to the way that it was even if that plant is taken down. Establishment of these plants is a firm decision that requires careful evaluation and constant monitoring.
As the water crisis continues to present itself, the environmental impact of the proposed methods of harnessing and delivering water will be crucial to note. This should be necessary with any major altering of the natural environment. Marine environments are just as delicate as environments that exist on land. This is just another complication to the already multi-faceted concept of freshwater management. As discussed, the water crisis will only get worse, so it will be important that these systems continue to work. But if the environments have been altered in a damaging way, we cannot expect these systems to continue to work during times when we need them most.

**Recommendations**

Desalination will become an increasingly important method for delivering freshwater as demand continues to increase. It is especially suited as being a supplemental water supply source for Libya for several reasons. The coast is relatively long and unpolluted, which provides an easily accessible and virtually unlimited source of water. Also, the major population centers are located close to the coast. Since desalination has been in the country since the 1960s, experts agree that local experience in desalination technologies is quite common in Libya. The cost of desalinated water is expected to decrease since domestic water sources are being exhausted both economically and environmentally. In addition, the use of desalinated water helps to take care of some of the stress that is placed on the finite aquifers. Less costly water will be better utilized at the national level and will strengthen the role of desalination in the sustainable development of Libya (Abufayed and El-Ghuel 2001).
Upon review of the available resources, it is obvious that desalination will in fact be a necessity and should be further expanded. Given the current state of the GMRP, it is especially important that these technologies continue to grow. As long as expansion of the technology can take place in a way that is economically viable, it will continue to contribute to the water supply that the GMRP is already delivering. Once the GMRP is finished and the desalination plants continue operating as they have been for decades, Libya will have a complicated but suitable solution to their freshwater problem. While the contribution of the desalination plants might seem trivial in comparison to the quantities of water that are delivered from the aquifers, it is imperative that they remain operational. We have already seen what happens when the GMRP is attacked directly. Should another such incident take place, the continued expansion of the desalination plants on the coast will prove worthwhile. For more efficient use of water resources, better demand management should be considered as well. Perhaps the use of graywater or some employment of reusable resources can be implemented to increase efficiency and promote better practices. No data could be found on whether or not these strategies have already been implemented.

Desalination and the Possibility of Conflict

Like the GMRP, desalination plants are another instance of a country’s attempt to further explore and exploit its water resources. There are many desalination plants on Libya’s coast and they all serve as attempts to further expand the country’s infrastructure. According to our adaptation of Le Billon (the water conflict argument), this increases the likelihood of violence in the country. In addition, these
desalination plants are drawing water from a water source that is shared by many countries. Even though it is not a freshwater source, it is likely that the impact that these desalination plants have on the Mediterranean Sea will draw the attention of other countries. Since multiple countries are using the Mediterranean Sea for multiple purposes, this could be a source of conflict at some point in the future.

Wolf’s fourth characteristic that was identified by Cohen and Frank in Agnew’s presidential address comes to mind in this discussion of desalination plants. The continual use of the Mediterranean Sea could result in water issues stemming from territorial claims that are put forth by neighboring countries. Constant desalination can affect the tides and the marine ecosystems of the Mediterranean and the consequences will likely have an impact on the activity of other countries. Although this is not a direct instance of a dispute over a source of freshwater, it still has to do with water provision and a strategy that is used to harness and deliver freshwater by one territory.

Both desalination and the GMRP are expansive and intrusive infrastructures. Their complicated nature makes Libya vulnerable. Because of the fact that the people of Libya cannot simply go to a body of freshwater to meet their water needs, the possibility of conflict in the region over water is much higher. This is because of the fact that these structures can be overtaken and used to exercise control over its people. The fact that water is a necessity for people to survive does not necessarily mean that people will be more civilized when it comes to quarrels over water. It can easily be seen as an opportunity to force an entire country into a situation where they will have to rely on an outside entity that has taken control of the only means they have to obtain safe and reliable water.
Chapter 5

Conclusion

Libya’s water provision methods combined into one system is multi-faceted, complicated, delicate, and still expanding. For an arid country, it has done well for itself. The purpose of this system is to bring water to the people at no cost. Access to water is rightfully seen as a basic human right. If and when the GMRP is completed and desalination plants are completed as planned, Libya will have access to sufficient water for a long time. Gaddafi’s vision will hopefully become a reality at some point. It will truly be a marvel for a desert country to have access to ample freshwater. It is likely that systems such as Libya’s will start to develop in other countries as the quality and quantity of surface water is called into question.

However, the discussed intricacies of these methods leave a lot of room for mismanagement. As the political climate undoubtedly changes and global climate change ensues, it is likely that conflict will arise again. Political strategies need to be explored further in addition to the useful developments that we discussed in the first chapter. These authors tend to lean on these political strategies as if violent conflict is not an issue that should be of concern. There have already been and are incredibly delicate political situations in Bolivia and Israel/Palestine in addition to the NATO conflicts in Libya that took place in 2011. It is unrealistically optimistic to say that political negotiations will continue to take place because people will suddenly become more civil due to the fact that they are dealing with a vital resource. It is for this very reason that violent conflicts are a very real possibility. As countries become desperate, their values are likely to change.
Agnew’s assessment of water politics provides us with a geographical perspective on the water crisis. The perspective is not urgent and puts a lot of faith in political processes. His six romances serve as his explanation of the “different ways in which defining or confining the political currently predominate.” He believes these views are a misconception of politics and they displace practical politics in the hunt for an “overarching abstract principle of the political.” These romances are used to support his point that politics is a practical activity rather than the application of an idealized theory. In a political environment where the resource that all life depends on is being called into question, how practical will politics remain? We have seen the intricacies of the GMRP and desalination plants. The physical geography of Libya in addition to its delicate and expansive infrastructure has already proven itself vulnerable. The consequence was that a large portion of the population did not have access to running water for an extended period of time.

In their assessment of Wolf’s work on water conflicts Cohen and Frank implied that politics will be a suitable strategy for water conflicts in the future. They identify four main characteristics of water politics that were examined by Wolf that were crucial in negotiating peaceful outcomes. However, these characteristics can be flipped to argue that they are the very reasons why water politics are so delicate and violent outcome is a strong possibility in the future. The first characteristic says that all sides need water so one side should not possess a singular right to water that is located on a boundary. Aside from the fact that this has already been disproven in the Israel/Palestine conflict, it is possible that this will be disproven in Libya as well. NATO’s attack on the GMRP shows how simple it would be for Libya’s water supply to be used to exercise power over its people. The same can be done using the desalination plants on the coast. In addition to the geography literature that was
mentioned throughout this thesis, further geographical research could be done in Libya in the form of spatial analysis of the available water resources.

In the second chapter, we discussed the nature of oil conflicts and the reasons why oil leads to conflict. Le Billon’s three arguments can easily apply to water conflicts. If oil has such a strong impact on conflict, then water definitely will. Wars over oil are already happening in the Middle East. It has been a center of controversy for decades. The motives are commonly control of oil in certain regions as a means to bring in more money. For water, the motive will be to survive. If violent conflicts over oil have already happened, how can one say that they are unlikely to occur over water? Libya’s infrastructure adds multiple levels to this argument. What we modified to become the water conflict argument (from the oil conflict argument) states that the more a country exploits, explores, and consumes water, it is more likely that violence will occur. In fact, using Le Billon’s logic, the very existence of the GMRP and the desalination plants automatically increases the likelihood of violence in these regions because they exist for the very purposes of water exploration, exploitation, and consumption. The more they expand, the more likely violence will become.

The methods used in Libya bring to mind a term that was mentioned in Agnew’s presidential address. It is what he refers to as the larger “drama of economic and urban growth versus nature.” This is the concept of water being used as an ally of elites versus its natural state of being. So in Libya, water was diverted from its natural, putative state in the desert aquifers and the Mediterranean Sea to support cities and population centers that are unnatural and likely not sustainable. Agnew explains this concept using Los Angeles and Las Vegas, which have also diverted water from far away to support themselves. With humans living in places
where they really are not supposed to in such great numbers, more invasive infrastructures like the ones in Los Angeles and Las Vegas are likely to be built. While it is difficult to imagine massive projects like the GMRP and the desalination plants in Libya, the reality is that there are structures that serve the same basic purposes closer to home. This is not to say that the same issues that were seen in Libya will be seen in the U.S., but it is certainly something to keep in mind. This similarity is striking. The infrastructure that allows this diversion reveals a large area of vulnerability for any territory. These structures can be used to exercise power over the people who rely on it. Since water is a fixed local resource, it can be used in Libya as a lever to exercise power over its citizens. This has already occurred as we saw with the NATO bombings of the “military facility” that was actually an integral part of the GMRP.

NATO’s intentions in the bombings of the GMRP are unclear. After review of multiple scholarly articles and press releases that discuss the incidents, it is difficult to conclude exactly what the end goal was. We cannot say with certainty that Libya’s water supply was used as a lever against them so that they would be under NATO’s control. However, NATO’s actions are a perfect example of what would happen if the water supply was attacked. People cannot survive without water. If they have to depend on an outside entity to grant them access to it, then they will be at the mercy of said entity. It is a very sad premise for the future of the area, but NATO’s actions show that it is in fact a very real possibility. Their actions also seem to disprove the potential good that multinationals can do in the face of such a crisis. Typically, these organizations are called in to help the people of a country in need. But NATO’s missile strikes in Libya will likely cause the people to be weary of multinational organizations taking interest in their country.
Violent conflict could easily be on the horizon. Political measures are immensely helpful. But as freshwater becomes scarce, it is hard to believe that political negotiations will eliminate the possibility of violent conflict. History tells a certain story but it cannot be used as an unconditional point of reference for conflicts, especially those concerning natural resources since the availability of many of the vital natural resources in the world will diminish. Just because violent conflicts have not occurred over water after review of 4,000 years of history does not mean that it will never happen. Libya’s delicate situation can be seen as an example of this. Its immense and complex infrastructure serves as a dangerous necessity that can be overtaken. This spells danger for the future. The issues that Libya is currently facing could very well be seen in other parts of the world in the future.
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