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Advancing Water Management Strategies in Morocco

by

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Abstract

This project provided recommendations for the Kingdom of Morocco, a country projected to experience a decrease of water availability by 30% by 2030. Interviews and site visits with Moroccan stakeholders from government, civil society, university, and industry, yielded information on initiatives employed to counteract the predicted decline of available water. Recommendations aimed to improve Moroccan water management and included strengthening communication through town-hall style meetings, promoting collaboration and awareness through utilization of the internet and social media, and developing a farming extension program and interactive educational outreach programs for students.

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Executive Summary

Introduction

The Kingdom of Morocco is working to mitigate the effects of a decline in water availability that is projected to worsen as a result of changing rainfall patterns. Morocco, situated in a semi-arid climate zone, receives an average of 346 mm (13.6 in) of rainfall per year, roughly half the rainfall experienced in the United States. Morocco employs a multi-sectoral approach to combat the effects of climate change, integrating efforts made by government ministries, universities, and NGOs.

The Moroccan government has launched water management programs to counteract the effects of climate change on water availability. Moroccan universities are focusing on innovative technologies to improve current techniques, and NGOs are employing a hands on approach to improve the citizen's quality of life. Strategies employed in this endeavor include: enacting new management strategies, developing sources of potable water, and expanding public awareness of the importance of environmental conservation.

The goal of this project is to support Ribat Al Fath for Sustainable Development, an NGO that brings society's environmental concerns to the government, in their efforts to improve Morocco's environmental sustainability policies. This report analyzes the current state of water management using a multi-sectoral approach to seek varied perspectives on current water strategies and offer recommendations based on the information gathered during an eight week investigation period in Morocco.

Important Context about Water in Morocco

Water is one of the most important resources in Morocco. Today, water access is 100% in urban areas and 94% in rural areas. Distribution is controlled by the National Office of Electricity and Potable Water (ONEE), a central water management agency established by the 1995 water law.

In order to ensure the availability of potable water, purification techniques such as desalination and wastewater treatment have been integrated into Morocco's water management strategy. There are currently 62 wastewater treatment plants in Morocco, owned and operated by ONEE. Recycled wastewater can be used for agricultural purposes in place of potable water. The

ten desalination plants along the Atlantic Coast of Morocco are expected to increase in number as Morocco further develops this industry. However, these plants have a substantial construction and operating cost that limits progress toward this goal.

The Ministry of Agriculture, in conjunction with the Ministry of Water and the Ministry of the Environment, is in the process of implementing the Plan Maroc Vert or Green Morocco Plan. Designed to modernize the agricultural sector, this plan supports several projects to improve farm efficiency. Included in this initiative is a new method of irrigation, drip irrigation, which greatly reduces water consumption on the farm by allowing water to be directly absorbed by the crops.

Water is a crucial resource as it is directly related to Morocco's economy in that 85% of water is used in agriculture, a sector that commands 15% of the kingdom's gross domestic product (GDP).

Methods

The objectives of this project were as follows:

1. To understand the perspectives of stakeholders including the government, academic experts, residents, industries, NGOs (Non-governmental organizations), and farmers invested in water sustainability.
2. To establish an understanding of the current state of water management through visits to relevant sites and organizations.
3. To analyze the efficacy of current policies and initiatives in reaching the overall goal: adaptation to the decreasing water supply.
4. To offer recommendations based on findings drawn on interview analysis, background research, and comparative benchmarks from other countries

Elected officials, administrators, NGOs, farmers, and the private sector were all represented in the team's program of field interviews and site visits. The interviewed stakeholders were involved in the domains of water, energy, and human development. Key stakeholders were evaluated using the Strength Weakness Opportunity Threat (SWOT) analytical tool, yielding a main list of findings.

From these findings, recommendations were made in the areas of communication, awareness, education, and public policy.

Findings

The key findings focus on agriculture, water production, and public awareness and are as follows:

1. The government of Morocco is implementing plans in order to mitigate the impacts of climate change.
2. Moroccan universities are developing innovative solutions to the challenges of clean water access and limited water supply.
3. Some of Morocco's ministries have common goals and overlapping focuses. Despite this, there is limited communication between ministries when working towards these goals. Inter-ministerial commissions exist, but most meet once or twice a year.
4. The government of Morocco is focused on water supply development. They are developing projects for new dams, sanitation facilities, wastewater treatment plants, and desalination plants.
5. Pillar I of the Green Morocco Plan, which deals with large investments, or farms bigger than five hectares, has more resources dedicated to it.
6. Drip irrigation subsidies are available to qualifying farmers as part of the Green Morocco Plan. The farmers must front the cost of material acquisition and installation, but are reimbursed a certain amount depending on the size of the farm.
7. The interaction between the government and the citizens is limited, especially in rural areas.
8. Public awareness of the decrease in water availability is not high. Citizens in water-plentiful areas of Morocco do not seem concerned about the availability of water.
9. Government outreach and education programs exist for primary school students, but field trips to the education centers are complicated for the schools to organize.
10. There are NGOs that complete hands-on projects that can affect large, positive change in target communities. These groups also serve as educators and communicators in the areas they serve.

Recommendations

The following list of recommendations was made after completing extensive interviews and field visits in Morocco, with the goal to further develop Morocco's water management system. These recommendations could be implemented to work concurrently, however they were designed to work independently.

1. **Awareness** and discussion frequency on the importance of water conservation **at the primary school level should be increased**. Environmental education programs should be expanded to reach new populations and, ultimately, become more effective.
2. **Partnerships between schools and NGOs** will make field trips more feasible.
3. **Science fairs** at the secondary school level will encourage creativity and awareness of environmental issues. Youth are an underutilized source for new, innovative ideas.
4. **Increasing stakeholder communication is very important**, especially in the case of government projects implemented in rural areas. Regular meetings facilitated by NGOs, in which community concerns can be raised to project managers, are one method of increasing communication. Another is the parallel track approach, which requires the consideration stakeholders to be involved and understand the reasoning behind policies.
5. The World Literacy Foundation could **provide solar tablets to facilitate government communication with people in rural communities** as part of a pilot project for Morocco.
6. More **in-depth farming extension programs** funded and executed by NGOs could be instituted that assist farmers with new agriculture techniques and present farmer-to-farmer cooperatives.
7. **Legislation** could be implemented mandating water efficient buildings.
8. **Increasing web presence** will benefit citizens and the international community, strengthening interest in international partnerships with Morocco.
9. A program of **text or audio alerts** could be developed to immediately warn people in rural communities of severe weather situations, public awareness events, and life threatening situations.
10. Regulations **advancing the water efficiency of plumbing fixtures** in new buildings and water efficiency in the maintenance of green spaces could be drafted.

Conclusion

Morocco is making progress in advancing water management strategies. Programs spanning multiple organizations aim to improve water security in the country. With these in place, Morocco can become a pioneer in the water management sector and could easily be globally recognized as an active, state-of-the-art country at the upcoming conference of parties, that is dedicated to the proper administration and implementation of innovative and sustainable water management practices. The World Literacy Foundation has shown interest in forming a partnership with Ribat Al Fath, working to gain funding from the World Bank by presenting our rural literacy recommendation as a pilot project for Morocco. This funding would greatly aid in Morocco's plans to further cutting edge developments in water management. However, this framework was not just for the country as a whole, but also for the generous individuals of Morocco, like this small farming family from Had Brachoua.

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Nomenclature

AES Agricultural Extension System

CMAs Catchment Management Agencies

FAO Food and Agriculture Organization of the United Nations

GDP Gross domestic product

HCFELD Haut Commissariat aux Eaux et Forêts et à la Lutte Contre la Désertification (The High Commission for Water, Forests and Desertification Control)

INDC Intended Nationally Determined Contribution

INDH Initiative Nationale pour le Développement Humain (National Initiative for Human Development)

MEMEE Ministry of Energy, Mining, Water, and Environment

NOAA National Oceanic and Atmospheric Association

NGO Non-governmental organizations

ONEE Office National de Electricité et de l'Eau Potable (National Office of Electricity and of Potable Water)

ONHYM Office National des Hydrocarbures et des Mines (National Office for Hydrocarbons and Mines)

ORMVAG Office Régional de Mise en Valeur Agricole du Gharb (Regional Office of Agriculture Development in the Garb)

OSU Oregon State University

SPANNA Society for the Protection of Animals and Nature

SAEP South African Education and Environment Project

SWOT Strength, Weakness, Opportunity, and Threat

UIR University International Rabat

USAID United States Agency for International Development

USDA United States Department of Agriculture

1. Introduction

In the 1960s, the Kingdom of Morocco began the implementation of a national water strategy orchestrated through the collaboration of the government, private sector, civil society, and universities. The Moroccan government has demonstrated the importance of water in Article 31 of the Moroccan Constitution, which states: “The State, public institutions, and local authorities shall seek to muster all the means available to facilitate equal access of citizens to their right to ... access water and a healthy environment, [and] sustainable development.”

This comprehensive plan to provide potable water to all inhabitants began 55 years ago with the construction of dams and reservoirs. Since then, it has evolved into a full-fledged framework detailing policies, constructing regulations, and outlining specific programs for agriculture, groundwater, transportation, public awareness, and creating a system of checks and balances for these components. This framework has given Moroccan citizens access to potable water in 100% of urban and 94% of rural areas, made possible by a water infrastructure consisting of 13 water transfer systems, over 1,100 km (684 mi) of pipeline, 139 dams, and 10 desalination plants (Moulay Hasnaoui, personal interview, September 11, 2015).

Current per capita availability is 760,000 L/year (2,000 gal/year), but that availability is expected to fall to 560,000 L/year (1,479 gal/year) by 2030 (Moulay Hasnaoui, personal interview, September 11, 2015) due to diminishing rainfall, a result of climate change (Abdelfadel, 2008). Decreasing rainfall could be related to a projected increase in the average temperature of 1.5-2.5°C (2.7-4.5°F). This increase in average temperature raises the susceptibility of lakes and dams to evaporation. Erosion and pollution also contribute to the loss of available fresh water. Throughout the country, land is becoming less fertile as arable soil layers are being lost to erosion by water and wind, causing dams and reservoirs to fill with silt. Arable land is also being lost as salination and desertification rates increase due to urban development. Similarly, mining and quarrying are causing deterioration of the natural environment and, specifically, soil and water quality (Said 2012, *Projects: Water and Sanitation 2010*).

There are many projects and initiatives in place to adapt the kingdom to the reduced water availability and combat negative human impacts on the water quality. Morocco’s universities and research facilities are working to develop more effective wastewater treatment and desalination techniques. The government and NGOs are working with the agriculture sector to implement more

efficient techniques of irrigation and the conservation of groundwater. NGOs interact both with the government and with citizens. Some NGOs work with communities to increase awareness of water issues, conservation methods, and to offer aid to farmers implementing new technologies. Other NGOs lobby the government to bring about new legislation, encouraging water conservation and awareness as part of a policy of sustainable development.

The goal of this project was to assist the Moroccan environmental agency Ribat Al Fath by compiling an analytical document on water management in Morocco that details assets and offers strategies for advancement in policy, awareness, and communication in Morocco's water management system. This was done by identifying existing strategies, programs, and accomplishments. A discussion was then held amongst the group to identify key opportunities for improvement based on background research, multi-sectorial interviews, and field visits conducted over an eight-week investigation period.

2. Background

Morocco faces projected decreases in potable water, necessitating considerable management of this precious resource. To better understand the management situation, information was collected on both the current state of water and how water relates to different aspects of Moroccan life. First, the issue of water acquisition and distribution was examined from both accessibility and transport perspectives. In response to the water situation outlined, a review was conducted of the major water-focused programs being implemented. Water purification practices were examined, including wastewater treatment and desalination plants. Agriculture, a major factor in the Moroccan water landscape, is discussed in the final section of the background.

2.1 Current State of Water in Morocco

2.1.1 Current Water Legislation

In 1995, the Loi No 10-95 Sur l'Eau (Water Law 10-95) was put into effect, which sought to regulate the distribution of water. The law shifted the government's focus from acquisition of water to a more sustainable management of existing resources. Loi No 10-95 Sur l'Eau established river basin agencies responsible for the collection and distribution of surface water, and a review board for the regulation and management of water conservation and sanitation.

In Morocco, water is considered a human right, and sources of water are considered public domain unless rights are granted otherwise. The 1995 law set up a system of water distribution that would be controlled by the National Office of Potable Water, currently the Office National de Electricité et de l'Eau Potable (National Office of Electricity and of Potable Water, ONEE), the largest water provider in Africa (Loi N° 10-95 sur L'eau, 1995).

2.1.2 Current State of Water Access in Morocco

The Initiative Nationale pour le Développement Humain (National Initiative for Human Development, INDH) launched by King Mohammed VI in 2005 played a pivotal role in improving the state of Moroccan water. Currently, the urban population has full access to water, with 94% access in rural areas (Moulay Hasnaoui, personal interview, September 11, 2015). Due to the INDH project there has been a significant improvement in water access. as in 2009 and 2004 potable water access levels for the country were 87% in urban areas and 50% in rural areas (WHO/UNICEF, 2014). Today, major sources of water for households include tap water, groundwater, rainwater, bottled water, and surface water.

Water is supplied by ONEE to towns for distribution to the citizens. In some towns the citizens pay ONEE directly, while in others ONEE supplies water to a private company that then distributes it to the citizens. In Rabat, Casablanca, Tangier, and Tetouan a Public-Private Partnership is utilized. In this system, the government awards five-year contracts to private water companies that provide water to individual municipalities (International Development Research Centre, 2005, Moh Rejdali, personal interview, September 22, 2015). Veolia, a French company, provides water and electricity to residents of Rabat under the name Redal. Veolia serves as the bridge between ONEE and consumers.

2.1.3 Water Distribution

Water meant for human consumption originates from one of two sources. One source, wells, supplies individuals and households, and contributes to municipal water systems (Hickey, 2008). Municipal water sources draw water from reservoirs, the second source. In Morocco, 139 different dams are used as reservoirs. Water from these reservoirs is treated and stored before being diverted into the water mains that distribute it. There are 13 main water lines in Morocco, spanning 1,100 km (680 mi), that can pump water at rates of 210 m³/sec (275 yd³/sec). Service lines branch

off of water mains to service individual houses. Water transport pipes are often old, and deterioration can cause leaks of up to 40% of water input to be lost between the source and consumer. Across 640 distribution centers, the average water loss is 27%, a number the Ministry of Water has a goal to decrease by 7% before 2020 (Moulay Hasnaoui, personal interview, September 11, 2015).

2.1.4 Freshwater Sources in Morocco

The country draws on seven major river basins: Loukkos, Moulouya, Sebou, Bou Regreg, Oum, Tensift, and the Souss-Massa. All but the Loukkos originate in the Atlas Mountain range. These stream-fed basins heavily rely on mountain snowmelt in order to replenish their reserves (Doukalli, 2005).

Morocco has an extensive system of dams, which mobilize a total of 17.6 billion m³ (4.6 trillion gal) of water (Moulay Hasnaoui, personal interview, September 11, 2015). There are 139 total dams in Morocco, 13 of which are major water sources.

The Bou Regreg Dam can accommodate 1 billion m³ (264 billion gal). Evaporation, however, can reduce the amount of water that this major dam that supplies to the Gharb region, the country's most fertile region (Civil Society and Water Administration of Sebou River Basin, n.d.). Evaporation reduces the water availability by 50 million m³/year (13 billion gal/year), with summer peak evaporation rates as high as 10-15 million m³/month (2.6 trillion gal-3.9 trillion gal) (Director of Communications (ONEE), personal interview, September 11, 2015). This dam provides an example of the evaporation problems experienced by both larger and smaller dams. Water obtained from the Bou Regreg and other dams requires purification before use.

The water from the Bou Regreg Dam will go to a sanitation plant owned by ONEE for purification. ONEE produces 1 billion m³/year (264 billion gal) of potable water, with its first sanitation plant built in 1976 outputting 5 million m³/year (1.3 billion gal). Sanitation services provided by ONEE reach 72% of the population (Moulay Hasnaoui, personal interview, September 11, 2015). These treatment plants purify both dam water and greywater. The plants managed by ONEE are equipped to treat water to three different levels of quality. Two of these levels are suitable for only agriculture and one is suitable for drinking (Director of Communications (ONEE), personal interview, September 11, 2015).

Regulated water resources for the country total 22 million m³/year (5.8 billion gal), where surface water provides 18 million m³/year (4.7 billion gal) and groundwater yields 4 million m³/year (1.1 billion gal). Morocco experiences a rainy season, where some northern regions of Morocco can experience 1,800 mm (70.8 in) of rain per year, whereas the south can expect less than 200 mm (7.9 in) (Doukkali, 2005). On average, the country of Morocco experiences 346 mm/year (13 in) (Morocco, 2013).

The World Bank defines internal freshwater resources as internal river flows and groundwater from rainfall. Morocco's average annual availability of renewable internal freshwater is 879 m³ (232 thousand gal). (Renewable Internal Freshwater, 2015).

The average internal freshwater resources for Morocco have major implications for water strategy and management, as groundwater reserves are not readily replenished by rainfall. Indeed, groundwater reserves are decreasing annually despite attempts to limit consumption through the regulation of wells (Moulay Hasnaoui, personal interview, September 11, 2015). Due to the effects of climate change, the country is facing a projected five to twenty percent decrease in annual rainfall over the next 40 years, and increasing frequency of extreme climatic events such as drought and flooding (Moulay Hasnaoui, personal interview, September 11, 2015).

The fluctuating and relatively small amount of rainfall Morocco receives forces the country to look to other, more reliable methods of water acquisition. This reality encourages the country to utilize techniques that recycle and reuse water.

2.2 Efforts to Improve Water Security in Morocco

In response to Morocco's decrease in potable freshwater, in 2011 the constitutional council enhanced the constitution to include the principle that water is a human right. The King also launched the INDH in 2005, in response to which many new programs have been funded. These programs cover broad categories, but with the common goal of improving the quality of life in Morocco. Programs of water purification, as well as plans for reduction of water use in agriculture, have also been launched.

2.2.1 Current Projects Using Foreign Aid

The INDH was created using a loan of about \$100 million (MAD 9.6 million) from various international organizations and foundations to create a "massive and high profile program designed

to reduce poverty and close the social gaps in the national fabric” (World Bank, 2012), part of which included expanding and repairing clean water infrastructure in both rural and urban parts of Morocco. The World Bank and the USAID, two major sponsors of the INDH, have helped fund projects developed and proposed by local, less well funded organizations. Funding is readily available for Morocco, as the kingdom has access to funding from the World Bank and the African Development Bank, as well as foreign investment. The increasing gross domestic product (GDP) of Morocco demonstrates to investors that the country is a secure investment. As of 2012, the debt as a percentage of Moroccan GDP was 60%, much lower than that of the United States, at 96% (Central government debt, total (% of GDP), 2013).

The World Bank has invested approximately \$1.5 billion (MAD 14.5 billion) in Moroccan water infrastructure in a variety of projects. These undertakings include: Building a wastewater treatment plant in the Tidilli area, replacing aging water pipes in the village of Outerbate, installing a secondary pump in Aghbalou village, recycling of solid waste in urban cities, increasing access to sanitation services in Azilal, Benimellai, Khourigba, Safi, Yousofia, Settat, improving productivity in Oum Er Rbia basin, expanding access to potable water in rural areas, and reforming the government’s environmental policies (World Bank, 2012). (For a representative list of past, present, and future projects see Appendix 4.1.)

2.2.2 Water Purification - Wastewater Management

Wastewater treatment is relatively new to Morocco. Prior to 2009, recycling and purifying facilities were independently owned and competed against one another. This caused nearly all facilities to fail, forcing them to close due to high overhead and running costs. The Moroccan government responded by centralizing the wastewater treatment industry under ONEE. ONEE has built 43 wastewater treatment plants utilizing stabilization ponds in rural settings. Stabilization ponds are used to separate hazardous materials and heavy metals from water. These ponds, which have a low running cost, need little maintenance, and are easy to operate, have improved the efficiency of the operation of the plants (Salama, 2014). The country’s goal is 100% wastewater recycling and treatment by the year 2030 (Salama, 2014).

Morocco currently has a total of 62 wastewater treatment plants. The total length of wastewater treatment pipe is about 13,000 km (about 8,000 miles). About 80% of urban centers in Morocco use this network. There are six plants with primary level sanitation (capacity 100 thousand

m³/day or 26.4 million gal), 40 plants with secondary level sanitation (capacity 240 thousand m³/day or 63.4 million gal), and 16 plants with tertiary level sanitation (capacity 161 thousand m³/day or 42 million gal). Primary level sanitation is used to remove solid waste. Secondary level sanitation is used to remove the dissolved organic waste. Tertiary level treatment is just a continuation of secondary treatment to remove more organic waste (Salama, 2014). Treated wastewater is mainly used in agriculture.

According to Office National des Hydrocarbures et des Mines (National Office of Hydrocarbons and Mines, ONHYM), mines always properly dispose of the water that is used. Since mines are very important in the western sahara economy, it is very important that they manage water correctly. The method used to dispose of used water involves a standing pond, where an impermeable tarp is laid in the ground where wastewater can then be dumped. In these ponds, heavy metals and hazardous materials settle at the bottom and the water evaporates leaving concentrated hazardous materials in the tarp after the process is complete. From there, the materials can be properly disposed of without harming the environment (Amina Benkhadra, personal interview, September 28, 2015).

2.2.3 Water Purification - Desalination

Morocco is investing in desalination plants to increase water resources in coastal areas. Inland areas are focusing primarily on wastewater treatment. In the limited space of the urban coastal cities, a desalination plant is often the most efficient way to provide water to local residents. These plants generally operate using one of two methods, membrane filtration or distillation.

The membrane processes can be broken down into two major groups, reverse osmosis and electro dialysis. The largest desalination plant in Morocco, Laayoune Desalination Plant, is run by ONEE and uses reverse osmosis to remove the salt from seawater. This plant combines this cleaning process with brackish water, making it even more efficient and versatile.

The plant is located in the southern coastal city of Laayoune, where it is so dry that the only reliable water source is the sea. This plant provides 26,000 m³/day (6.9 million gal/day) of clean drinking water for the residents of Laayoune and the surrounding areas (Elazhar, 2013). Recently, the multinational company Abengoa was awarded a 20 year, \$111.5 million (MAD 1.1 billion) contract from the Moroccan government to design, build, and operate the country's largest desalination plant, which will be capable of producing 100,000 m³/day (26.4 million gal/day) of

water (Doom, 2014). This plant will operate using reverse osmosis, the same procedure used at the Laayoune plant. The increase in plant size is a response to predictions of decreased water availability as a result of climate change, including a paper by Mohammed Karrou of the Moroccan Agricultural Research Agency, an offshoot of the Food and Agriculture Organization of the United Nations (FAO). His report predicted an increase in national temperature of 1.5-2.5 °C (2.7-4.5°F) over the next 30 years, as a direct result of worldwide increases in CO₂ emissions (Burger, 2014, Doom, 2014).

There are several considerations to be accounted for with desalination plants, however. These include costs, both monetary and energy, and environmental impacts. The Laayoune plant, for example, cost approximately \$23 million (MAD 222 million) to build and releases brine back into the ocean, which changes the salinity of the water. The cost of producing 1 m³ (264 gal) of drinkable water using the process of reverse osmosis, as done in the Laayoune plant when it was at the capacity of 13,000 m³/day (3 million gal), is the equivalent of \$0.07 (MAD 0.71) (El Azhar, 2013). The cost used to be much higher but with the recent upgrades in post-process remineralization methods from a caustic soda to a lime based saturator, it is much more cost effective. This has mitigated the problem of abnormal wear on transport pipes since its implementation in 2012. This is a good example of innovation, higher production coupled with a lower running cost, and less downtime for repairs (El Azhar, 2012). The energy cost of desalination is still a limiting factor in the number of plants created, though there is research into using solar power to reduce the running cost of desalination plants.

2.2.4 Research and Development Related to Water

The scientific research sector in Morocco is growing. In the 1990s, sponsored research started to become more prevalent. According to a member from the Moroccan Association of Science, researchers are funded to generate reports, which are then passed to the sponsor. Projects that seek to apply the results of research initiatives are sometimes unfunded, leaving research unapplied. A multi-step initiative is being put in place to help fix this process. First, a ministerial office for research at the Secretary of State level was established. An institutional framework was created that included an Inter-ministerial Committee of Scientific Research and Technological Development. Loi No 01-00 was passed, which reorganized the higher education system to better facilitate research and technology transfer activities. Committees were created that select the

research proposals that receive funding. Currently, there is a potentially effective framework for encouraging the research and development sector. These programs are recent, however, and have not yet had time to fully take effect (Azzoui, 2013).

The academic research sector in Morocco is contributing to adaptation of the country to the challenge of water scarcity by developing and implementing technologies. An example of this is the wastewater sanitation lab of Université Ibn Tofail, which is carrying out research and development for water treatment technologies. The University is also affiliated with a wastewater station that serves an area currently without access to purified water. The station, paid for by donations from sponsors, produces 0.7 m³ (185 gal) of water cleaned to 90% purity-safe for drinking- with an input of 1 m³/hr (264 gal/hr). The output of the station provides water for 1,500 students at a school in the area. Both solar and wind energies are used to power the station, making it a self-sufficient unit (Elgueddari Zouhair, personal interview, September 9, 2015).

2.3 The Agriculture Sector: Key Focus of Water Management Concerns in Morocco

2.3.1 Current State of Water in Agriculture

The agricultural sector, which accounts for 15-20% of the country's GDP and 40% of employment, uses 80% of total water resources (Said, 2012). This makes it an essential focus of any effort to reduce water expenditure. The major agricultural sectors of Morocco are in the north, where rainfall is the most predictable and plentiful (Figures 1 and 2) (Berkat, 2006). Most Moroccan

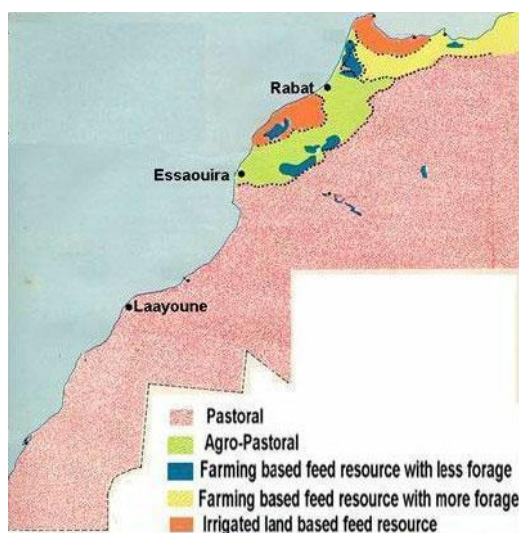


Figure 1: Farmland in Morocco (MARA)

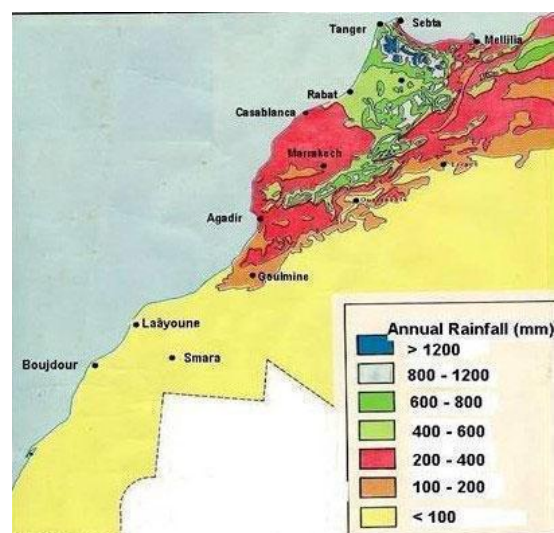


Figure 2: Rainfall in Morocco (MADPRM)

farms that have an irrigation system use surface irrigation, which has high evaporation rates. Initiatives sponsored by the government and NGOs have prompted farms to transition to drip irrigation, a tactic that releases water directly to the plants at a slower rate than traditional irrigation and is more water efficient (EPA, 2015). Subsidy programs have been available for conversion to drip-irrigation since 2009. Currently, 16% of the nine million hectares (35,000 mi²) of agricultural land employs drip irrigation.

“With its fertile land, Morocco has the potential to be largely self-sufficient, producing enough food for its domestic market, as well as for export. However, cyclical droughts present a continual threat, causing regular hardships in the agricultural sector.”

(Morocco Climate & Agriculture n.d.)

The climate change taking place in Morocco will reduce the amount of rainfall expected in the coming years. The figures below note the regions that receive enough rainfall for agriculture. With the predicted decrease in rainfall the area of these regions is expected to diminish by about 30% by the year 2030 (Abdehaldi Bennis, personal interview, 2015).

2.3.2 Irrigation Strategies

Surface irrigation, sprinkler irrigation, drip irrigation, and subsurface irrigation are four major types of irrigation: while each serves the same purpose, delivering water to plants, the methods have varying degrees of efficiency when applied to different farms.

Surface irrigation (Figure 3) is the act of applying water to the surface of the soil. This can be done in ditches or furrows, or can be carried out by flooding the entire field. This could be a cause of soil erosion, if fields are not well maintained.



Figure 3: Surface Irrigation (J. Vanuga)

Sprinkler irrigation (Figure 4) allows for the amount of water that reaches the plants to be more controlled. It simulates rainfall by spraying water on the fields in controlled amounts. It could be called a type of surface irrigation, as water is still applied directly to the surface of the soil, but the amount of water that is used can be controlled. Sprinkler irrigation requires a lot of equipment.

Subsurface irrigation relies on the artificial raising of the water table to cause water to be more available to the roots of the plants. Pipes beneath the soil are used to deliver water to the roots of crops. This method reduces the likelihood that water will evaporate before being absorbed into the soil, but requires a substantial installation process.

Drip irrigation (Figure 5) is the delivery of water to rows of crops by perforated pipes placed close to the crops that gradually release water to the plants as needed. It also requires installation, but reduces the likelihood of water evaporating before being absorbed into the soil.



Figure 4: Sprinkler Irrigation (G. Alexander)



Figure 1: Drip Irrigation (E. Platko)

3. Methods

3.1 Mission Statement

The goal of this project is to assist the NGO Ribat Al Fath by compiling a document on water management in Morocco that details assets and offers strategies for advancing water purification, water conservation, agriculture, and environmental sustainability. This document can be used as a reference to focus the organization's environmental policy efforts.

3.2 Objectives

Background research on the state of water in Morocco identified four main areas of inquiry that were identified prior to arrival: purification, conservation, agriculture, and environmental change. These focus areas were used to guide subsequent interviews and field visits conducted in Morocco. Focus areas were revisited after all interviews and site visits had been completed, given the increased understanding of the project and water management situation by the team.

Objectives:

1. To understand the perspectives of stakeholders including the government, academic experts, residents, industries, NGOs (Non-governmental organizations), and farmers invested in water sustainability.
2. To establish an understanding of the current state of water management through visits to relevant sites and organizations.
3. To analyze the efficacy of current policies and initiatives in reaching the overall goal: adaptation to the decreasing water supply.
4. To offer recommendations based on findings drawn on interview analysis, background research, and comparative benchmarks from other countries

In order to meet the objectives of the project, the team conducted interviews with various stakeholders involved in water management: government ministries, representatives from regional offices, NGOs (non-government organizations), and universities. While interviews were conducted with small farmers working with an NGO, it was difficult to adequately gauge the opinions and perspective of the general public because only one village that was receiving aid was interviewed.

The project group visited other sites including: a water purification plant, a dam, a water-pumping station, small rural farms, and a larger irrigated area. Information gathered during the interviews and visits was then combined with background research and used to analyze the current system of water management in Morocco. This analysis was accomplished by identifying trends, commonly identified areas of improvement, and the strengths of the current system.

As a final deliverable, a report was written for Ribat Al Fath, and will be used by that organization as a reference for potential lobbying. Thus, the report has been written with Ribat Al Fath as its intended audience.

3.3 Data Collection

3.3.1 Protocols

Before traveling to Morocco, the team received approval for the project from the Internal Review Board at WPI. Interviews were the main data-collecting protocol used in this project. As required by the Internal Review Board, the full purpose of interviews were disclosed to the interviewees.

Kawtar Abendag, a student at Al Akhawayn University doing an internship at Ribat Al Fath, often acted as interpreter for the team. As a fluent speaker of English, French, and Moroccan Arabic, her translations greatly assisted in making communication between the project group and the interviewees smooth and engaging. Interviews were recorded, with the permission of the interviewees, and the information was entered into a central database, from which it was categorized and analyzed. After the interviews, thank-you letters were emailed to participants with follow-up questions attached.

Interviews were tailored to suit the subject's level of education and area of expertise, and the project group attempted to phrase questions to learn as much as possible during each interview while instilling as little bias as possible. Several of these interviews were impromptu, which made formal preparation difficult, but gave the team the chance to evaluate situations and ask questions based on the flow of the conversation. Interviews were often conducted after receiving a briefing or tour, depending on location. Over a cup of tea, as customary in Morocco, the project group would ask questions and have an open discussion with the interviewee.

3.3.2 Purification

The purification sector of water management was analyzed by gathering information about current purification projects carried out by stakeholders including the Ministry of the Environment, ONEE, and Université Ibn Tofail. The team conducted interviews to learn about the National Waste Recovery Program and several sanitation projects carried out by ONEE nationwide, visited purification plants, and interviewed the professionals that run them. A tour of ONEE's pilot wastewater treatment plant on the Bou Regreg River was conducted after the interview where the team learned of the processes used for purification by the plant manager. The team also toured a water purification research lab at Université Ibn Tofail and a small solar and wind powered purification plant set up by the same university in an area without access to government-provided water infrastructure. An interview with the Ministry of Environment aided in the team's understanding of the origins of pollution and guidelines protecting groundwater from contamination.

3.3.3 Conservation

The Ministry of Environment and ONEE, among other stakeholders, provided substantial information on conservation efforts, including current policy and the Kingdom's future plans. As conservation awareness and practices need to be incorporated in water management at all levels, the team interviewed the rural farmers of Had Beraoucha, a rural village near Khemisset, about their knowledge of conservation techniques, and their water conservation techniques in the home. Experts from NGOs, government, and institutions were interviewed in order to further understand the communication across all sectors, and to gain further insight into innovative academic research being done.

3.3.4 Agriculture

The agricultural sector's major development project, Plan Maroc Vert (Green Morocco Plan), works to increase water efficiency and is carried out by the Ministry of Agriculture in conjunction with the Ministries of Water and the Environment. This plan aims to improve the efficiency of water use in the agricultural sector using methods such as the implementation of drip irrigation systems on farms. The team investigated the implementation of drip irrigation as a case

study in communication between the government and the people and current agricultural practices in Morocco.

Interviews conducted with the farmers of Had Brachoua and the president of a local NGO that works with them to promote sustainable farming practices, which provided insight into water use and conservation practices on small farms. This also gave the farmers an opportunity to vocalize their concerns and opinions related to water management practices and the government. Interviews were also conducted with engineers and technicians from the Office Régional de Mise en Valeur Agricole du Gharb (Regional Office of Agriculture Development in the Garb, ORMVAG) in tandem with field visits to a regional water filtration and pumping station and some local fields that were irrigated by that station.

3.3.5 Environmental Change

To understand the severity of environmental change as well as the problems of deforestation and biodiversity decline related to water management, interviews were conducted with the Ministry of Energy, Mining, Water, and Environment (MEMEE), ONEE, and a meteorologist. These interviews yielded information on governmental awareness of climate and environmental change, the plans that have been made to combat and adapt to it, as well as the challenges that are being faced in carrying out such plans.

3.4 Challenges

Many sources of bias were potentially brought to the project, which could have had many potential consequences including distorted interpretation of information gained during interviews. Biases could have been brought to the project by the sponsor, the interviewees, or project group.

Working so closely with a single NGO, particularly a lobbying one, presented an opportunity for bias. In order to maintain autonomy from the views and existing relationships of Ribat Al Fath, the project group researched organizations independently prior to discussing upcoming interviews with the sponsor.

Abdelhadi Bennis and Kawtar Abendag created an interview schedule that represented many different stakeholders, many of which were interviews conducted with high level, government officials. These were very helpful in understanding the big picture of water management in Morocco and gave our project the direction of a broad recommendation section. There were interviews that

focused on small farmers or rural communities that also proved useful, however it was difficult to not be swayed by the official present with us during these interviews. Because of the large focus on big stakeholders, the project is focused on the big picture, whereas the next IQP group could focus more closely on small stakeholders.

The personal biases of the team were the most difficult to confront, as they were the most difficult for the team to identify. Being aware of the potential for bias on the part of the project group, the team sought perspectives from Abdelhadi Bennis, Kawtar Abendag, and the project advisors. The project group also favored group discussions in order to limit individual member biases.

Biases of potential sources were considered before any information gathered from that source was used in the report, and the identification of biases was an important part of the analysis process.

3.5 Data Analysis

To guide identification of findings and recommendations, Strength, Weakness, Opportunity, and Threat (SWOT) analysis was conducted for each of the major stakeholders in water management in Morocco. SWOT analysis was introduced to the project team by the sponsor contact, Abdelhadi Bennis. In addition to the traditional SWOT categories, the project team identified the main role of each stakeholder in water management. The result of this analysis is included in Appendix F of this report. In addition to SWOT analysis, the team also had an open discussion to generate findings.

During this open discussion the project team reviewed the information learned during interviews. At times, different interpretations of interview information were presented by different project members. In these cases, the team would consider and converse about the interpretations until consensus was reached, or, if a consensus could not be reached, seek to clarify with the interviewee in a follow-up email. These discourses often proved the most fruitful, as they presented an opportunity for the information to be carefully analyzed from different perspectives.

4. Findings

4.1 Introduction

The Moroccan government recognizes the challenges the Kingdom will face as a result of deforestation and climate change. Action plans and strategies are being developed in response to these problems. Projects based on these action plans are primarily large-scale and prioritize implementation of innovative technologies. The government is actively working to affect change, including developing outreach and education programs for the citizens and offering aid in the form of subsidies, but its efforts are complicated by lack of communication infrastructure and the education level of the citizens.

Meanwhile, researchers are looking into technologies related to the issues the government is working to tackle, but projects to apply the results of their research are scarce due to lack of funding. Direct Contact NGOs work directly with citizens engaging in hands-on projects. These organizations have developed effective communication methods and familiarity with locals, and can motivate local communities to bring about positive change.

The project team interviewed Ministries, researchers, and NGOs and gathered information during field visits to projects and farms. The following section lists the findings the project team developed based on the information gathered during these interviews and field visits.

4.2 The government of Morocco is implementing plans in order to mitigate the effects of climate change.

Projects launched in order to combat the effects of pollution and desertification include the Green Morocco Plan, part of which includes replacing one million hectares (3,900 mi²) of high water usage grain crops with fruit plantations that will help reduce erosion, and the Intended Nationally Determined Contribution (INDC), an overarching program that has led to a multitude of smaller projects to reduce the country's non-renewable energy usage, water consumption, and pollution. One project initiated as a part of the INDC is the Moroccan National Energy Strategy, the goal of which is to produce 42% (6,000 megawatts) of the country's energy consumption from renewable sources by 2020. Other projects include the National Waste Recovery Program and the National Liquid Sanitation and Wastewater Treatment Program, which aim to reduce pollution by creating a

mainstream household waste plan, building landfills and recycling centers, and connecting homes to sewage treatment facilities (Rachid Tahiri, Personal Interview, September 16, 2015).

Trees can aid in groundwater reserve preservation, reduce erosion, and prevent desertification. Unfortunately, 4,500 hectares (17 mi²) of forest are lost to forest fires each year, with another 1,000 hectares (3.9 mi²) consumed by urbanization. The Haut Commissariat aux Eaux et Forêts et à la Lutte Contre la Désertification (The High Commission for Water, Forests and Desertification Control, HCEFLD) has an assistance program that provides tree seeds to farmers. This commission also assists cooperatives by providing funding to conserve wooded areas instead of turning them into farmland. These projects aim to mitigate the effects of climate and environmental change while promoting the development of the country.

4.3 Moroccan universities are developing innovative solutions to the challenges posed by limited clean water access and a decreasing water supply.

Several universities around Rabat have degrees in Sustainable Development. University International Rabat (UIR) is one such university, with majors in renewable energy engineering and active environmental clubs. At UIR, projects are being developed include the use of solar power to run desalination plants and a dew collection device that captures water from humidity in the air. The accomplishments of these student organizations include a solar-powered car developed by UIR's Energy Club, and are a source of pride for the university.

Graduate students at Université Ibn Tofail in Kenitra are conducting research on filtration systems used for reverse osmosis purification. Université Ibn Tofail has developed a small, solar and wind powered wastewater treatment plant that supplies a school of 1,500 students in a small community near Kenitra. The community, which is located in an isolated area without access to tap water or electricity, uses groundwater contaminated with nitrates as its primary water source for drinking. Nitrate poisoning is serious, causing a variety of health problems including miscarriage. This station is currently the only one of its kind in Africa, but replication of this setup could provide clean water to communities across the country, if, as is the case with Université Ibn Tofail's project, donors could be found to fund the projects. Finance, understandably, can be a limiting factor regarding the realization of university projects. At UIR, funding was needed to begin a new project; jokingly, the Dean asked the project team to invest in their research. The efforts of the academic

sector represent an important resource for the government, as research can be applied in innovative government programs.

4.4 Some of Morocco's ministries have common goals and overlapping focuses. Despite this, there is limited communication between ministries when working towards these goals. Inter-ministerial commissions exist, but most meet once or twice a year.

There are 36 government ministries in Morocco, compared to the United States' 19 cabinet level ministries. Each of the Moroccan Ministries is further subdivided into commissions. These organizations have many opportunities for cooperation. Each ministry affects and is affected by areas that fall under the jurisdiction of other ministries, and thus it would be difficult for them to work independently. For instance, agriculture greatly affects water usage and economics, and is greatly affected by climate and environmental change. Therefore, it is essential that the Ministries of Agriculture, Environment, and Water have good communication and strong partnerships.

One potential challenge to this communication is the fact that the different parts of each ministry are separated by physical space. The Ministry of Energy, Mines, Water, and the Environment has a different building for each subset. The project group visited three of these separate locations, the Ministries of Water, Energy, and the Environment. The Ministry of Water and Energy were a short walk from each other, but the Ministry of Environment was a 10 minute drive away from the other two.

4.5 The government of Morocco is focused on water supply development. Projects for new dams, sanitation facilities, wastewater treatment plants, and desalination plants have all been implemented as part of this focus.

The purification sector has been expanded to include 10 desalination plants, 139 dams, and new wastewater treatment facilities. Novel strategies for irrigation, drip and sprinkler, are being implemented. A director at ONEE said that Morocco was currently at saturation for the production of water and due to this more plants would be built. Reducing the public's water consumption was not brought up by ONEE.

4.6 Pillar I of the Green Morocco Plan, which deals with large investments, or farms bigger than five hectares, has more resources dedicated to it.

The government has set aside MAD 17.6 billion and created 102 projects that cater to large farms. Small farms, less than five hectares ($>0.02 \text{ mi}^2$), have been allocated MAD 198 million and 22 projects (Aboufarris Alaoui, personal interview, September 29, 2015).

The energy strategy for the Kingdom also features large-scale projects such as those worked on by MASEN, a solar energy company that receives government funding to build large-scale solar plants as part of a program to generate sustainable energy for the grid, rather than small-scale solar plants that could bring power to communities that do not currently have electricity.

4.7 Drip irrigation subsidies are available to qualifying farmers as part of the Green Morocco Plan. The farmers must front the cost of material acquisition and installation, but are reimbursed a certain amount depending on the size of the farm.

The Green Morocco Plan aims to increase the use of drip irrigation from 114,000 hectares (440 mi^2) to 250,000 hectares (965 mi^2) by 2020 through the provision of drip irrigation subsidies to farmers. As part of Pillar II of the Green Morocco Plan, farms less than five hectares (0.02 mi^2) can have 100% of the cost of drip irrigation installation refunded by the government. If the farm is larger than five hectares ($> 0.02 \text{ mi}^2$), the government refunds 60% of the cost. To receive this subsidy, extensive paperwork must be filled out by the farmers and submitted for review. If the farm qualifies, the government will send a local official to the site for inspection. Should the farm pass, the farmer must then front the cost of the irrigation equipment, fill out an expense form, and submit it to the government, who will then reimburse the farmer. Depending on the location of the farmer and the supplier of the irrigation materials, the farmers install the equipment themselves or with the help of a field engineer.

Often, small farms will not pass inspection or will not have the capital required for installation. There are, however, NGOs that assist small farms with implementing more sustainable agricultural practices. The Association des Agriculteurs Modernes, which works closely with a commune in the town of Khemisset, is an example of this type of organization. This NGO teaches organic farming methods and helps farmers install irrigation systems fed by water pumped from wells.

4.8 The interactions between the government and the citizens are limited, especially in rural areas.

The project team's instructor of cultural norms, who grew up in a rural town, as well as, a small farmer, both indicated that their communities had little interaction with the government. In fact, the small farmer had never had government officials visit his property. At interviews with Ministries, including the Ministry of Water and the Ministry of Environment, it was brought to light that the government has difficulties enforcing legislation in rural areas. This legislation exists to protect groundwater reserves from overexploitation. Officials survey areas to enforce this legislation, but often find that wells have been dug that are not licensed.

At a pumping station supervised by ORMVAG in the Gharb region, the second most polluted in the kingdom, the project team learned that the government encourages farmers to use pesticides effectively, but their efforts are hindered by the movement of farmers and low accountability felt by the farmers.

The negative impacts of the lack of communication between the government and citizens becomes apparent when the government is working on projects. One such project is the installation of drip irrigation systems on farms. At the farm visited by the team in the Gharb region, farmers had started to break into water main outlets and vandalize the equipment put in place by ORMVAG, according to the field engineers installing the systems. According to the engineers, farmers vandalized the equipment because they believed the government was putting the system in place to restrict their water access. This incident points to a communication disconnect between the farmers and the government.

4.9 Public awareness of the decrease in water availability is not high. Citizens in water-plentiful areas of Morocco do not seem concerned about the availability of water.

The project team observed multiple instances of water usage that would be limited in water-deprived areas of the U.S., including watering lawns, washing cars, and having pools and fountains. Because the price of water does not give the population an incentive to conserve water, the public may not realize that potable water is becoming a scarce resource. These observations were mostly made in the northern areas of Morocco where rainfall is regular, though decreasing. In accordance

with these observations, there is uncertainty about the value the public places on water given the trends in rainfall and average temperature and projected reduction in annual water access per capita.

The Ministry of Water acknowledged the “low valorization” of water as a main challenge in the project team’s interview with them, but is working to valorize water through conversion to drip irrigation and a program to reduce water use by tourists and industry. This lack of value placed on water isn’t just an economic one, as it also seems to be based in the public’s general understanding of the availability of water. When asked about conservation efforts, the ministry mentioned that there weren’t many programs that reduced water consumption by individual citizens. If the public value of water is low, it is not simply due to the low financial cost, but also the lack of education of the citizens about its value.

4.10 Government outreach and education programs exist for primary school students, but field trips to the education centers are complicated for the schools to carry out.

In 2013, the Ministry of Environment built an education center in their Rabat building to teach school age children about the environment. However, the plastic coverings that remained on the computer towers hinted that the room had been used infrequently since its opening. Indeed, the spokesman for the Ministry of Environment said that it was easier to arrange field trips for private school children, as private institutions can provide transportation. ONEE also had pamphlets to be distributed to school age children, but these are only found on their website.

4.11 There are NGOs that complete hands-on projects that can affect large, positive change in target communities. These groups also serve as educators and communicators in the areas they serve.

NGOs such as the Society for the Protection of Animals and Nature (SPANNA) and Association des Agriculteurs Modernes do on the ground work to directly aid those in need. SPANNA has a veterinary clinic in the souk where the poor can have their animals treated for free. Education is integrated into all aspects of SPANNA’s program- the veterinary clinic provides opportunities for vet students to gain experience, and the NGO teaches both children and adults about home remedies, animal healthcare, and nature. SPANNA also has a farrier program and a van that travels to various rural areas to treat the animals in homes and on farms. The Association des Agriculteurs

Modernes and Slow Food Maroc transformed the community in the Had Brachou village by constructing vegetable gardens and teaching the inhabitants of the village how to farm sustainably to support themselves. The NGOs also began an effort to clean up trash in the neighboring woods, and set up an eco-tourism circuit in the area that provided a new source of income for the villagers.

NGOs commonly act to fill gaps in other assistance programs to assure that the needs of the people are met, and can make a difference in communities, but the most valuable thing about NGOs is the trust they have built in the communities they serve.

5. Recommendations

5.1 Introduction

The following section outlines recommendations that could improve certain areas of the Moroccan water strategy. This segment of the report aims to provide recommendations from a new point of view in the hopes that those recommendations can aid in Morocco's efforts to surmount this challenge. These ideas could function if implemented together, as water relates to all sectors, however these ideas can also be successful if implemented independently.

5.2 Education Programs in Schools

5.2.1 Primary School Age Education

The education of Moroccan citizens is key to conserving water. Implementing an education program that teaches children about environmentalism would help with the conservation of water. Educating children has a two-fold benefit, as children will bring what they learn at school home to their parents. As noted in the findings section, programs to educate children exist, but are not utilized to their fullest extent. If these programs were redesigned, they could prove quite effective. Two methods could be used to teach children about the environment: in-class learning and field trips. In class learning will provide students with background knowledge, and field trips will allow them to experience the joy and beauty of nature.

The United States Geological Survey, a branch of the U.S. government, has numerous information and educational materials for teachers online. Examples include Water Education posters for grades K-6, Desalination, The Water Cycle, and The Water Cycle: for Oceans, Groundwater, and many more (USGS Science Resources for Primary Grades (K-6), 2015). A website sponsored by the Moroccan government similar to the United States Geological Survey one would be invaluable for classroom education, providing teachers with the background knowledge necessary to educate the children. Posters hung up around the classroom could intrigue children and inspire them to learn more about the environment.

5.2.2 Field Trips

After learning about the environment in a classroom setting, children could gain an appreciation of the environment and understand the importance of protecting it through field trips.

For example, SPANA has an education program that will bring children from public schools out to their centers, where an animal handling program provides children with a hands on learning experience (Environmental Education, 2014). Partnerships between schools and industries or NGOs will help make these trips more economically feasible.

In Kenya, the South African Education and Environment Project (SAEP) found that educating children by allowing them to go out on hikes and clean up beaches was an effective strategy of teaching children about the environment. To fund these trips, partnerships were formed with organizations like the Cape Union Mart, who provides the program's food and transportation. They also partner with the Mountain Club of South Africa to organize hikes for the children, as well as with I Am Water for beach cleaning opportunities (Environmental Education, 2014).

5.2.3 Science Fairs

When children leave primary school, a continuation of the curriculum could include water collection and conservation science fairs. This would require students to go above and beyond by researching the issue and producing a report or complete a project constructing a device to aid in collection or conservation. This competition has three major benefits. The first increases public awareness and forces students to research the issue. The second is the generation of new ideas that could potentially be used in future large-scale projects. The third creates a bridge between the Ministries and primary education.

One important project to note is the Deep Root Irrigation Precipitation System, completed by two high school students from California. The system, which was designed for Morocco and its rural farmers, focuses on collecting dew to harvest crops in arid and semi-arid climates. This project was submitted to a larger competition and placed as one of eight winners (The D.R.I.P.S. Project, 2011).

5.3 Inter-stakeholder Collaborative Meetings

Face to face communication is crucial for building a constructive relationship between a government and its citizens. A technique that could be used to improve communication between these two groups would be to hold collaborative meetings orchestrated by NGOs and government representatives. This would grant an opportunity for the citizens to voice their opinions, concerns, and questions about policy and ongoing projects. It is important that the citizens feel their opinions

and problems are being listened to and considered. The citizens are stakeholders in government projects, and without their support projects will not be able to reach their full potential. Regular meetings between the government, the NGOs, and the people will provide opportunities for cross-stakeholder understanding.

Meetings such as these might avoid situations like the vandalization of irrigation equipment experienced by ORMVAG field engineers in the Gharb Region by educating farmers about the benefits of the new irrigation equipment, and allowing them to express concerns to the project managers. Through thoughtful, two-way communication, trust will develop between the farmers and those trying to help them. This sense of trust will be instrumental in ensuring that farmers and their government can work together to improve the farmers' lives. Meetings could use the framework established by SPANA, where once a week a field representative visits villages to hold this discussion. Ideally, NGOs and Ministries would be represented at the meetings.

Meetings between the Moroccan government and local communities has had positive results in the past. An anecdote from Amina Benkhadra at an interview with ONHYM described a phosphate mine that was supposed to be built in Agadir, but the people of the city rejected the plan out of concern that it would negatively impact the city's tourism industry. The mine was then slated to be built in Safi, however the people there were also concerned about the construction of a large mine in their hometown. Having no other options for the location of the mine, officials from ONHYM met with citizens of Safi to discuss the people's concerns. Through open discourse and compromise by both parties, an agreement was reached between ONHYM and the people of Safi that satisfied both parties.

There are several models that private companies use to effectively engage their stakeholders. Business for Social Responsibility, a global business dedicated to bringing together stakeholders for sustainable development, proposed a five step loop that can be used to incorporate stakeholder views into business plans. The approach involves setting an engagement strategy, defining the stakeholders that will be involved, establishing goals in preparation for stakeholder involvement, conducting engagement in a manner that allows equal contribution from each stakeholder, and identifying an action plan and redefining goals based on feedback from the stakeholders (Morris, 2012). In this plan, the concerns of the stakeholders are regarded internal issues to be considered and addressed rather than outside threats. This style of approach helps project managers ensure that

all stakeholders are on the same page and working together to implement plans of action to their fullest potential.

It is absolutely critical to ensure that the government and the people are working hand in hand. Without cooperation, projects will not be able to reach their full potential. In order to reach the citizens, the bridge between the NGO's and the government will also need to be strong. NGOs that work locally have ties with the people that are crucial to the success of endeavors like these meetings.

5.4 Combatting Illiteracy in Rural Areas

Illiteracy, which is especially prevalent in rural areas, is a barrier to government assistance programs, many of which require reading and understanding forms to take advantage of. The subsidy program for farmers to switch to drip irrigation offered by the government is an example of this. The farmer interviewed in Brachoua did not apply for this subsidy because of how complex the application was. The team reached out to the World Literacy Foundation for advice on how to solve this problem. It was proposed that this issue could be solved by establishing an educational resource such as a solar powered, off-the-grid tablet preloaded with video and audio messages explaining how to fill out necessary forms. This resource could remain at the farm and would allow the farmer to watch the videos as many times as needed to understand what needed to be filled out.

The World Literacy Foundation has shown interest in partnering with Ribat Al Fath to help combat the illiteracy issue. This partnership could mitigate the negative impacts of illiteracy in rural areas, and increase rural access to government aid programs.

5.5 Farming Extension Program

5.5.1 Educational Database and Workshop for Farmers

Extension programs are helpful ways to present the farmers of Morocco with new information. There is currently an official extension program for farmers in Morocco, the Agricultural Extension System (AES). As of 2014, the AES requires one employee to cover 12,400 hectares (48 sq. mi) and 1,930 farmers per year. In comparison, the U.S. has a very large network of extension programs for farmers. The United States Department of Agriculture (USDA) is partnered with universities around the country to provide extension programs. The extension services that are

currently offered by Morocco focus strictly on crop production, however the program could be expanded to include subjects like irrigation, crop variety, and basic accounting (El Bilali, 2014).

Hands-on workshops could be an effective training component of farming extension programs. These workshops would provide an interface between farmers and extension program workers. Once internet resources are more widely available, educational documents could be uploaded to a website maintained by the extension program that can be accessed by farmers.

The United States has an extension program executed by Oregon State University (OSU) that works closely with small farms in the areas surrounding the school. Their outreach methods include internet articles, in-person workshops, and a large annual conference. Education topics include crop variety, planting practices, livestock, and pastures. Internet resources allow OSU to keep information organized and accessible, and workshops allow for hands-on learning. This infrastructure would not be possible without a sponsor; the OSU extension program is sponsored by Northwest Farm Credit Services (Oregon Small Farms, 2015).

5.5.2 Farmer to Farmer Extension Program

An extension program in Kenya uses farmers to teach other farmers, educating a smaller group that could then spread their knowledge to other farmers in the area. The main difficulty of this lies in the selection of the “teaching” farmers. Communicators were ranked on two active communication methods - public forum announcements and training provided to fellow farmers - and passive methods - when other farmers started the conversation. It was found that 19 out of 48 expert farmers (40%) were not effective communicators, and that there were no correlations between demographic categories, like gender or age, and performance. There were, however, large motivational differences between good and poor disseminators. The primary motivation among effective disseminators was the desire to help others; others included social benefits, monetary benefits, and interest in the job (Franzel, 2011). Even after the termination of the extension program, some farmers were still disseminating information (Lukuyu, 2012).

Components of OSU’s extension program and Kenya’s farmer-to-farmer education program could be applied to Morocco to achieve greater knowledge sharing and awareness in the agrarian community.

5.6 Public Awareness and Alert Systems

5.6.1 Social Media Campaign

Both the Moroccan government and NGOs are investing time and money into working to solve the problems created by climate and environmental change, but these efforts are complicated by the current infrastructure of communication between them and the citizens of the country. Increasing the reach of NGOs and government ministries may be as simple as creating a Facebook page. Almost 20 million of Morocco's 33 million inhabitants use the internet, up from ten million in 2011 (African Internet Users, 2015). Both the government and NGOs can use this growing internet presence to their advantage in communicating their objectives to the citizens. The creation of websites and social media pages that educate and engage the technologically active community could tremendously increase awareness of issues such as environmentalism and the importance of water conservation.

In 2009, President Barack Obama issued a directive that required the opening of “new forms of communication between government and the people” (Executive Order 12958) In response, federal government departments and agencies increased their presence on social media platforms such as Facebook and Twitter, allowing citizens to keep up with government communication easily and conveniently. Municipal governments followed this example, allowing Americans to access information from federal and local governments on Facebook and other frequently accessed social media applications. This improved the government's ability to reach out to and educate the people and provided a simple platform for citizens to voice concerns in the form of posts or messages on the government pages.

For example, a resident of Worcester, Massachusetts who follows the Facebook page of the city's Department of Public Works and Parks can learn of any changes in the weekly household trash collection schedule as soon as they are announced.

The Department's page is also used for education. On October 7th, the department made a post that detailed potentially hazardous items of household waste, why they were hazardous, and how to safely dispose of them. (City of Worcester, 2015)

Any person with internet access is able to



Figure 6: A Facebook Post by the Department of Public Works and Parks in the city of Worcester, MA

follow state government social media pages. The Commonwealth of Massachusetts, for instance, has Twitter accounts for its offices, several of which use other social media platforms including Facebook, Youtube, LinkedIn, Instagram, and Flickr. These accounts allow the offices to share what actions are being taken in an environment that allows people to directly respond. The Twitter feed of the Governor of Massachusetts, Charlie Baker, made several posts in October, 2015 referencing an education law allowing the creation of several charter schools in Massachusetts. These posts outline what actions are being taken as well as why they are being taken. (Baker, 2015) These posts act as a bridge between the government and the people, allowing for closer and more frequent interactions between the two.

5.6.2 Text Message Program

An increase in web presence for Moroccan government agencies, NGOs, and companies could also create job opportunities, as social media pages and profiles require monitoring and maintenance. Web presence is also an important way for Morocco to publish information to the rest of the world. Many universities, government ministries, and NGOs have expressed a desire for international partnerships and investors. Information and data about projects published on websites could serve to attract potential partners or investors.

Social media is one way that NGOs and government organizations might more easily reach out to citizens, but there are citizens who do not have reliable access to the internet. However, as cell phone use is prominent in both urban and rural areas, text message communication could be an effective method of distributing information directly from the source to the people. Automated voice messages could be sent in any language to reach the illiterate population. Possible partnerships or agreements with communication companies, such as Maroc Telecom, could provide these messages free of charge for this program. By providing this service for free, citizens will be more likely to answer phone calls and respond to these messages. This communication has other applications, including warning citizens of severe weather that might affect them as soon as it is detected, allowing them time to prepare.

It is important that citizens are not charged for receiving these communications. The cost could be covered in a governmental budget, and deals could be made with the telecommunications company. If citizens are asked to pay for the service, they will be unwilling to sign up for it, and the program will have reduced effectiveness.

The National Oceanic and Atmospheric Association (NOAA) in the United States has a smartphone application that sends out emergency alerts in the event of severe weather, missing persons reports, and national emergencies. These wireless emergency alerts are meant as a supplement to other types of broadcast media, providing an automatic alert to emergencies that can prompt immediate action that has saved lives. The Morocco National Meteorology Direction could partner with communications companies, such as Maroc Telecom, to develop a similar warning system for severe weather events such as floods. These types of alerts will provide an opportunity for citizens to become more aware of what is going on around them, be it weather, water, or health related.

5.7 Reduction of Demand by Conservation

5.7.1 Legislation for New Residential and Commercial Buildings

Conservation practices should be strongly incentivized. Currently, Morocco does not have water conservation legislation that applies to commercial or residential buildings (Zerouali, 2009). Implementation of this legislation could ensure that new buildings have appliances that are water efficient, including clothes washers, automatic dishwashers, and showerheads. Such legislation could also mandate that all new toilets are less than 6 liter flush (1.6 gal), and faucets are either automatic or use leak proof fixtures.

As an example of such legislation, the U.S. Energy Policy Act of 1992 mandated that all non-commercial toilets sold in the U.S. be less than 6 liter (1.6 gal) flush (Energy Policy Act of 1992, 1992).

5.7.2 Legislation for Green Spaces

According to the President of the region of Temara, a desire of the citizens was to enhance current and create new green spaces. However, green spaces in a drought prone climate are high cost and high risk due to the water required to keep them healthy. The government of Victoria, Australia has addressed this problem with restrictive laws on the use of water in green spaces:

1. Water from a hand-held hose must not be used for any purpose (whether or not the use is subject to a permanent water saving rule) at any time unless the hose: is fitted with a trigger nozzle, is leak-free.

2. A public garden or lawn area or a playing surface cannot be watered except: with a hand-held hose, bucket or watering can at any time, with a watering system fitted with a rain or soil moisture sensor between the hours of 6 p.m. – 10 a.m. on any day
3. Water cannot be used in a fountain or a water feature unless the fountain or water feature recirculates the water. (Permanent Water Saving Rules, 2014)

The creation of more green spaces is helpful for both enhancing the beauty of the city as well as increasing the environmental quality. In making green spaces it will be necessary to think ahead and implement legislation to reduce the use of water consumption while watering green spaces. One method to help is to grow plants that utilize less water, for example, the Blue Mediterranean Fan Palm or the Perennial Cardoon. Another potential method is, instead of using water from an open hand held hose, using a nozzle will help drastically reduce the water use. It will both increase the area of ground watering and decrease the water runoff and evaporation. While enforcing the legislation may be difficult, it is a good first step in reducing the water use in green spaces.

5.8 Official Presence and Incentive Programs in Rural Areas

As reported by the FAO, stakeholder participation is an essential provision for sound groundwater resource governance. Morocco faces the particular struggle of regulating groundwater usage and preventing the pollution of local water supplies due to agricultural runoff. This challenge is not easily overcome, but case studies from the US and South Africa exist that could be used as models for Morocco's work in this field.

An interview with a small farmer in Khemisset brought forth the issue of limited personal contact with local government representatives in rural areas. The farmer never had access to a local official. The local government had never visited the farm to ascertain the wellbeing of the family or evaluate the farm in terms of agricultural policy. An important first step in applying current policies is to acclimate the public the presence of local officials. Visiting local populations would also create an opportunity for hearing concerns people have, and officials could use this opportunity to assist citizens with any problems they might be having. It is understood that "rural [officials], more than their urban counterparts, often work with lower budgets, less staff, less equipment, and fewer written policies to govern their operations" (Weisheit, 1994). Officials also have the challenge of reaching these remote areas, often not accessible by car or all-terrain vehicles. In the remote regions

of Iowa, USA, however, the Department of Justice found that, “rural [officials] appear to be more efficient than urban police and more respected by the public” (Weisheit, 1994).

A rural official operation may be slow to start, but over time efficiency will increase as the job is better understood public respect and trust is established. Officials will only earn this respect if communication with the public is open, and the officials treat the public with the utmost respect. The public must be made aware that the purpose of the officials is to help, and the officials must be aware and considerate of the difficulties and concerns of the public. For this reason, the officials should be first introduced as educators and resources, rather than policy enforcers. While educating the villages about conservative use of natural resources, it is suggested there is leniency in reprimand. Suddenly increasing official presence and placing restrictions on a group of people that are not accustomed to regulations could, potentially, degrade the relationship between the government and the citizens.

An incentive program would benefit the villages being visited by local officials and help local citizens realize that the government is here to help them. Increased presence in rural areas would allow local officials to work with the residents to develop good conservation practices. This framework of law enforcement introduction is designed to encourage collaboration between officials and villages.

The efforts made in Namibia and South African focus primarily on the policy and structure of laws placed on rural communities. An unsuccessful program in Namibia involved the Ministry of Rural Development issuing licenses to farmers and villagers. Different license classifications allowed access to different amounts of water for consumption, and water sources had a regulator attachment that issued different amounts of water depending on what license an individual had. However, destruction of the regulators prevented this program from succeeding.

The experience of the field engineers in the Gharb region of Morocco suggests that this approach of regulating water would result in the vandalization of the fixtures. When Namibia tried implementing license classifications it failed, but this failure led the Namibian government to realize that “it is often politically difficult and time consuming to amend legal provisions and organizational arrangements for groundwater governance, and thus it is advisable to follow a ‘parallel-track approach’” (Christelis, n.d.).

Parallel track approach methodology:

1. Educating stakeholders about complex groundwater situations so that stakeholders can participate on a more informed basis
2. Enabling and nurturing stakeholder organizations so they and not [the] government can lead on local processes, ensuring all stakeholders are properly represented irrespective of their individual economic and political influence
3. Establishing a sound and implementable groundwater resource rights system for controlling large users and protecting small ones – appropriate from the overall basin and groundwater body perspective and adapted to the operative level of community-based management

Stakeholder involvement in the creation of regulations will ensure that the rural population's needs are met and concerns are addressed, while bringing about an understanding of the reasoning behind the policies that affect their daily lives. It is also important to note that there are no punitive measures in this methodology.

Similar to Namibia, South Africa requires all water users to register with the Department of Water and Sanitation as part of an initiative to protect groundwater reserves. However, South Africa uses Catchment Management Agencies (CMAs) that act as liaisons between the government and the people. While these agencies regulate consumption, they focus on, “involving local communities in the decision-making processes, in terms of meeting basic human needs, promoting equitable access to water, and facilitating social and economic development.” (Water affairs, 2014). There are a total of nine CMAs managing community relations in South Africa.

These case studies were compiled to provide a strategy framework that could be used to aid in enforcing resource management in the rural communities of Morocco. Using a mix of the strategies used in Namibia and South Africa could reduce the potential for program failure. It is crucial that Morocco considers, involves, and educates all stakeholders involved. The ‘parallel-track approach’ utilized by Namibia is an effective way to include all stakeholders in the creation of regulations. A framework like the CMAs could be used to provide feedback to the government on the status of programs, and help maintain relationships between stakeholders after implementation has begun. Increasing rural government presence alongside the ‘parallel-track approach’, and creation of organizations like the CMAs would create a rural engagement strategy that would engage all stakeholders in the conservation of groundwater reserves in accordance with environmental policy.

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7. Appendix

Appendix A: Historical Context: Effects of French Colonialism

Drastic changes in Moroccan water practices and agriculture were instituted during the French colonization of Morocco, many of which still influence the country today. The French Protectorate in Morocco was established in 1912 with the signing of the Treaty of Fes. During World War I, France looked to Morocco as a new source of wheat and cereal crops, both in short supply at the time. It was believed that the dark soil of the Atlantic Plains would be rich with organic material and good for grain production, therefore France took steps to turn Morocco into a breadbasket. French colonists in Morocco were given large tracts of land, from 150 to 400 hectares, between 1916, the beginning of the wheat policy, and the agricultural crisis of 1930.

Moroccan wheat production grew in prominence and output, even while wheat production in France began to recover. In order to maintain their colony in Morocco, the French artificially inflated the price of imported wheat and forced farmers in Morocco to harvest enough wheat to export to France, essentially filling a quota. Eventually, farmers in France became resentful of the preference given to the imported Moroccan wheat and the negative impact it had on the domestic market. In 1930, Morocco suffered a severe drought and a plague of locusts, causing a famine. After 1931, due to pressure from farmers in France and the apparent fact that Morocco could not continue to produce wheat on a massive scale, the French Protectorate decided to support cultivation of fruits and vegetables in Morocco instead, which grew to maturity faster than in France. Today, Morocco produces cereal crops and citrus for export in part as a result of practices implemented during the colonial period.

Morocco gained its independence in 1957, under King Mohammed V, who reigned for four years until his death. His son, Hassan II, came to power in 1961. Hassan II was an autocratic ruler in many domestic aspects, but moderate in his interactions with the West. He rejected the idea of a religious government, winning him the favor of the United States. After several years of absolute rule, Hassan II rewrote the constitution of the country to include a parliament. Several socioeconomic reforms were instituted following several failed coups. In the final years of his reign, Hassan II instituted several social and economic reforms in order to appease the citizens before his son, Mohammed VI, took the throne. Among these was a law that began the regulation of water in Morocco.

Appendix B: Moroccan Projects

This section provides a list of some Morocco projects that have been completed and some that are ongoing. It is not a complete list of the projects because not all of Morocco's projects are registered with the world bank or US affiliated websites. This list was generated prior to the arrival in Morocco and confirmed after the visit.

6.2.2 List of Sources

Tidilli Area: Build A wastewater treatment plant (USAID, Association of Tissilite)

<http://map.usaid.gov/PublicProjectDetail?id=a0cd00000011q7rAAA&cid=Morocco>

Outerbate: Replace the aging water pipes (USAID, El Khair Association)

<http://map.usaid.gov/PublicProjectDetail?id=a0cd00000011q7wAAA&cid=Morocco>

Agbalou village: Install a secondary pump (USAID, Aghbalou Association)

<http://map.usaid.gov/PublicProjectDetail?id=a0cd00000011q7XAAQ&cid=Morocco>

Berkane, Taourirt, and Figuig Provinces: Increase incomes of small holder farms through crop switching, diversification, and intensification. (USAID, The Near East Foundation, CWMAD)

<http://map.usaid.gov/PublicProjectDetail?id=a0cd00000011q7cAAA&cid=Morocco>

Moroccan Cities: Recycling of Solid Waste (World Bank)

<http://www.worldbank.org/en/news/press-release/2015/02/12/130-million-support-recycling-improved-solid-waste-management-Morocco>

Morocco Rural Communities: Access to safe and reliable drinking water for rural communities (World Bank)

<http://www.worldbank.org/en/news/press-release/2014/04/29/world-bank-group-strategy-Morocco-new-projects>

Morocco Government Reforms: Environmental policies to improve the management of natural resources (World Bank)

<http://www.worldbank.org/en/news/feature/2014/01/24/Morocco-takes-the-long-view-on-green-growth>

Azilal, Benimellai, Khourigba, Safi, Yousofia, Settat: Increase access to Sanitation services and reduce wastewater pollution (World Bank)

http://www.wds.worldbank.org/external/default/WDSContentServer/WDSP/MNA/2014/12/08/090224b0828f0cef/1_0/Rendered/PDF/Morocco000Moro0Report000Sequence010.pdf

Oum Er Rbia basin: To increase productivity and reach a sustainable use of irrigation water to overcome current and future water deficits (World Bank)

<http://www.worldbank.org/en/news/press-release/2010/05/27/Morocco--us70-million-to-promote-more-sustainable-use-of-irrigation-water-in-the-oum-er-rbia-basin>

Rural communities: Acces to potable water in rural areas (World Bank)

http://www.wds.worldbank.org/external/default/WDSContentServer/WDSP/MNA/2014/11/29/090224b0828a0c0f/1_0/Rendered/PDF/Morocco000Rura0Report000Sequence018.pdf

Rural Remote upland areas: Rehabilitation of medium scale irrigationschemes and related community infrastructure (World Bank)

<http://www.worldbank.org/en/results/2013/04/15/agriculture-results-profile>

Mountanous Regions: (A) Natural Resource Management; (B) Socioeconomic Infrastructure; and (C) Institution Building (World Bank)

http://www.wds.worldbank.org/external/default/WDSContentServer/WDSP/IB/2005/06/30/000160016_20050630093641/Rendered/PDF/32292.pdf

Urban Centers of Casablanca, Tangiers, and Meknes: Connection to water and sanitation services about 11,300 low-income beneficiary households (International Bank for Reconstruction and Development)

<https://www.gpoba.org/project/P102527>

Ouarzazate, Azilal and Benguerir: Finance drinking water supply to three medium sized cities and 260 rural communities, benefitting 480,000 inhabitants (European Bank for Reconstruction and Development)

<http://www.ebrd.com/work-with-us/projects/psd/once-water-supply.html>

Nador, Driouch, Safi, Youssoufia, Sidi Bennour and Errachidia provinces: Increase access to potable water (World Bank)

<http://www.worldbank.org/en/news/press-release/2010/06/15/us-218-million-for-Morocco-to-increase-access-to-water-and-expand-wastewater-systems>

Table 1: Project List

Date Of Projects	Active?	Where?	Main focus	Indepth Focus	Amount Spent
3/3/2011-3/2/2014	Yes?	Tidilli Area	To build a waste water treatment plant	Connect the village to the sanitation plant, re-use treated waste water	\$1,554,399.00
3/2/2011-3/1/2014	Yes?	Outerbate	Replace the aging water pipes	To also connect each house to a new pipeline so that women and children don't have to carry water everywhere.	\$204,984.00
3/2/2011-3/1/2014	Yes?	Aghbalou village	Install a secondary pump	Connect all neighborhoods to the sanitation system, protect the surface water and the drinking water system from contamination, and build public latrines for women.	\$296,482.00
11/29/2010-5/28/2013	Yes?	Berkane, Taourirt, and Figuig provinces	Increase incomes of smallholder farms through crop switching, diversification, and	Subsistence-oriented smallholders improve agricultural water management	\$899,036.00

			intensification		
2/12/2015 - 12/31/2015	Yes	Morocco, mostly in cities	Recycling of Solid waste	Making the jobs better for waste workers, More than 15 million people are now benefiting from upgraded municipal solid waste services	\$130,000,000.00
4/24/2015 - 9/30/2021	Yes	Morocco, Rural Communities	Access to safe and reliable drinking water supply for rural communities	Scale up multi-sector approaches for the and improve competitiveness and global integration.	\$ 223,600,000.00
12/19/2013- 12/31/2014	Yes	Morocco Govt Reforms	Environmental policies, improve the productive management of natural resources (inc water)	A multi-faceted national strategy aims to reduce fossil fuel consumption through increased energy efficiency and a shift to renewables, while investing in the better management of natural resources	\$ 300,000,000.00
6/15/2010 - 6/30/2017	Yes	Azilal, Benimella i, Khourigba, Safi, Yousofia, Settat	Increase access to sanitation services and reduce wastewater-related pollution	As well as to increase the amount of potable water	\$ 75,100,000.00
5/27/2010 - 6/30/2017	Yes	Oum Er Rbia basin	To increase productivity and reach a sustainable use of irrigation water to overcome current and future water deficits.	High efficiency drip irrigation, support farmers for better access to technology, financing, and markets, To give over the project to another agency	\$ 115,500,000.00
12/15/2005-	Closed	Rural	Access to potable water in rural areas	Improve wastewater management and promote good hygiene	\$ 112,470,000.00

11/30/2014				practices	
5/31/2001 - 12/31/2008	Closed	Rural remote upland areas	Rehabilitation of medium-scale irrigation schemes and related community infrastructure	Shift to higher-value horticultural and tree crops, 48 drinking water schemes resulted in halving the time spent fetching water and contributed to halving the incidence of water-borne disease.	\$ 42,400,000.00
12/22/1998 - 12/31/2004	Closed	Mountainous Regions	(A) Natural Resource Management; (B) Socioeconomic Infrastructure; and (C) Institution Building.	Natural Resource Management (US\$ 3.29 million at appraisal). This component included: (a) erosion control; (b) sylvopastoral land improvement; (c) forestry management; (d) fruit-tree plantations; (e) rehabilitation of small-scale irrigation schemes; (f) technical support to farmers; (g) training of technicians	\$ 5,800,000.00
1/29/2007 - Ongoing	Yes	Urban centers of Casablanca, Tangiers and Meknes	Connection to water and sanitation services of about 11,300 households		\$ 7,000,000.00
1/15/2014 - Ongoing	Yes	Ouarzazate, Azilal and Benguerir	Finance drinking water supply to 3 medium sized cities and 260 rural communities in the above regions benefiting over 480,000 inhabitants.	The loan will also finance the third phase of a nationwide Performance Improvement Programme.	\$ 70,235,750.00

6/15/2010 - 12/31/2015	Yes	Nador, Driouch, Safi, Youssoufi a, Sidi Bennour and Errachidi a provinces	Increase access to potable water	Increase the rate of sanitation access and wastewater treatment in 11 towns of the Oum Er Rbia	\$ 216,000,000.00
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Appendix C: Sanitation

A relatively inexpensive method of wastewater purification being utilized in other developing countries uses ponds planted with water hyacinth to purify wastewater. The water hyacinth plant removes bacteria and cleans the water. One significant issue with this method is evaporation, and the ponds provide a breeding ground for insects such as mosquitoes, which can spread disease (Kivaisi, 2001). Reed beds are an alternative to the water hyacinth plant, which remove parasites from the water and reduce water loss to evaporation (Mandi, 1998). Unfortunately, this alternative does not solve the issue of insect breeding, as this is also an open air, outdoor method. In a country as hot and dry as Morocco, open air cleaning ponds will lead to greater evaporation than production, rendering these methods practically useless in the south. However, it may be worth investigating the use of these in the mountains to the north.

Appendix D: Biodiversity

“Although Morocco is rich in biodiversity, this is now threatened, in large part because water resources are poorly managed; 35% of piped water is lost, and water stocks are being polluted with industrial and urban waste. Cultivable land is also compromised because of water shortages and soil erosion. These factors are seriously aggravating rural poverty, and the gap between the richest and poorest population segments has widened.”

-Said 2012

Biodiversity is being threatened globally by human activities. Twenty percent of Moroccan flora and 11% of fauna are endemic to that region, meaning that these species are found only in Morocco. Water loss due to overdevelopment and farming are causing species to become rare or endangered, which will eventually lead to a decrease in diversity. Water pollution combined with an increase in fishing activity is affecting the local marine life. The water purification technique of removing salt from seawater, desalination, is being practiced in Morocco with no restrictions placed on the quantity of waste brine expelled back into the sea. On a large scale, this could make the environment inhospitable for some native marine species. A severe change to the ecosystem could occur if five or six of these plants were constructed in close proximity of one another. Waste brine contains about 50% more salt than seawater, and can be detrimental to the coastal ecosystem when disposed of into the sea. Red tuna, red coral, red algae, and the monk seal are all impacted by these human activities. In order to correct these negative impacts, Morocco is currently developing an initiative called the “Halieutis Plan” which aims to protect marine life and prevent overtaxing of marine resources.

Increased urbanization has led to the loss of 31,000 hectares (120 mi²) of forest per year, and the resulting fragmentation of forests has accelerated species decline. The government has identified 154 forest sites with especially diverse ecosystems and has established 10 national parks to protect these areas and the species that live in them (Morocco - Country Profile: Biodiversity Facts, nd).

Appendix E: Forests

Overexploitation of forest and soil resources poses a threat to biodiversity and clean water. Forests are being cut down in order to create land for housing and to expose additional arable land. Planting trees in watershed areas filters many impurities from both the water and air (Watershed Forestry, NA). It can also help prevent erosion near dams, keeping them structurally sounder, longer. Forests also decrease evaporation rates and promote groundwater formation, which can later be used for drinking or irrigating crops. The water resource benefits provided by forests far outweigh profits from harvesting the wood. For example, Chinese forest water storage capabilities were estimated to be worth \$1 billion (MAD 9.6 billion), three times the projected earnings if the forests were logged (Stolton & Dudley, NA).

Appendix F: SWOT Stakeholder Analysis

	Role	Strengths	Weaknesses	Opportunities	Threats
Government	<ul style="list-style-type: none"> • Create legislation • Provide funding for projects and initiatives • Ensure legislation is followed 	<ul style="list-style-type: none"> • Access to external funding • Can pass legislation on national and local levels • Recognizes problems and makes efforts to solve them 	<ul style="list-style-type: none"> • Have the potential to be out of touch with the public • Bureaucracy • Lack of enforcement mechanisms • Lack of coordination 	<ul style="list-style-type: none"> • COP 2016 – show off Morocco and get foreign investment • Engage with the people • Develop new partnerships with other stakeholders 	<ul style="list-style-type: none"> • Global politics and power balances
Researchers and Academics	<ul style="list-style-type: none"> • Generate new technology and procedures 	<ul style="list-style-type: none"> • Access to external funding • Access to knowledge and instrumentation • Better suited to create solutions for Morocco than outsiders 	<ul style="list-style-type: none"> • Have the potential to be out of touch with the public • Require sources of external funding 	<ul style="list-style-type: none"> • Solve the problems of the country • Develop new partnerships with other stakeholders • Create innovative solutions and break onto the world research scene 	<ul style="list-style-type: none"> • Loss of funding • Competition in a global market
NGOs	<ul style="list-style-type: none"> • Fill gaps left by the other stakeholders • Serve as a bridge between people and government • Promote welfare of the people • Work on the ground with the people 	<ul style="list-style-type: none"> • Access to external funding • Run by people who care deeply • Localized • Actively work on publicity • On the ground work • Direct communication with the people 	<ul style="list-style-type: none"> • Affect small area • Need to work for grants 	<ul style="list-style-type: none"> • COP 2016 – show off Morocco and get foreign investment • Develop new partnerships with other stakeholders 	<ul style="list-style-type: none"> • Loss of funding
Farmers	<ul style="list-style-type: none"> • They are the society • THEY ARE THE MOST IMPORTANT THING. 	<ul style="list-style-type: none"> • Strength in numbers 	<ul style="list-style-type: none"> • Do not have access to external funding • Lack of education • Illiteracy • Some fear and distrust the government • Lack of awareness • Lack of faith in the ability of things to change 	<ul style="list-style-type: none"> • Engage and begin dialogue with the government • Develop new partnerships with other stakeholders • Improve quality of life 	<ul style="list-style-type: none"> • Directly impacted by success or failure of the other stakeholders