Aggies visit Guanajuato, Mexico

This summer 2015, students from Texas A&M spent two weeks in Guanajuato, Mexico focusing on the water, food, and energy nexus in the U.S. and Mexico. Students and faculty from the University of Guanajuato and from Texas A&M jointly worked and learned from each other during the study abroad course. The collaboration among binational students fostered the examination of contemporary issues in water resource systems, food and energy nexus accounting for economic, legal, political, social, cultural and international considerations.
The opportunity to study abroad, offers a unique and incomparable experience for students. When studying abroad, students are exposed to different cultures and are able to develop skills and abilities hardly obtained in a classroom. This summer of 2015, from August 16 to August 30, sixteen students from the Water Management and Hydrological Sciences Program (WMHS), three students from the Texas A&M School of Law, and fifteen students from the University of Guanajuato enrolled in the WMHS 602 study abroad course: “Contemporary Issues in Water Resources: Mexico and the U.S Water, Energy and Food Nexus” in the state of Guanajuato, Mexico. The coordination of the course was directed by Drs. Jose Soria, Gilberto Carreño (UG) and Rosario Sanchez (TAMU), and led by our faculty Drs. Ronald Kaiser, Gabriel Eckstein, Gina Warren and Rick Giardino. Together, they created a magnificent and diverse experience for students. The course also included a variety of field trips to illustrate some of the issues Mexico faces on these topics. From your students, we would like to extend a sincere “thank you” for the extraordinary study abroad experience that we will surely remember!

The group from Texas A&M arrived at Hacienda Santa Clara on Sunday. Hacienda Santa Clara is a study abroad center dedicated to foster a global outlook through multidisciplinary enrichment. It is a very lovely place, with all the accommodations needed for the course and even more. The personnel working in the Hacienda did their best to make us feel at home, and we were pleased to experience real traditional Mexican cooking with the added bonus of special treatment from Pablo Marvin and Federico Legorreta, the director and manager of the hacienda, respectively.

Hacienda Santa Clara is located just outside of the art and cultural mecca of San Miguel de Allende, Guanajuato, in central Mexico. San Miguel de Allende is known for its well-preserved Colonial and Spanish architecture. The downtown area is a mix of art galleries, souvenir shops, modern boutiques, and old stores. It is not only rich in Mexican culture but also attracts many foreign retirees, artists, and writers predominantly from the U.S. and Canada. Downtown there are narrow streets, and alleys, with no traffic lights. It is in general a very quaint place, full with musicians, artists, and street sellers, allowing for great attractions in a relaxing setting.

On Monday, the students from UG arrived to the Hacienda and the mixed group quickly left for the Laja River to make river profiles under the direction of Dr. Rick Giardino (TAMU) who showed procedures using a wide range of equipment (nobody could tell how many gadgets he had in his bag), starting with a digital level and a metric tape and going to more basic methods.

The first day we had presentations in form of videos from Drs. Rabi Mohtar and José Luis Castro. They each discussed important sustainability questions and challenges that Texas will have to face in the years to come. We heard from Dr. Castro about the conditions of water resources in Mexico, important differences between Mexican and U.S. institutions, and options that could be implemented to improve CONAGUA’s management strategies (National Water Commission).

The next day started with an overview of the state of Guanajuato economic and social impacts from Ms. Andrea Cecilia García Rivera. She demonstrated how important tourism is to the State of Guanajuato from an economic standpoint. We heard about the difference between the U.S. and Mexico water distribution systems for public supply from Mtro. Rafael Zarate, who ended his presentation with a friendly reminder to always clean your “tinaco” (roof water tank). We ended the day with the first...
The first week also included presentations from Dr. Eduardo Salazar Solís on agriculture production in Guanajuato, and the increasing problems with water consumption. Dr. Graciela María de la Luz Aguilar Ruiz talked about the nexus between water and energy in Guanajuato, creating a very illustrative exercise about the complicated relationship between the water demand from different users and the limited amount of water. The exercise brought to light the complex and difficult matter of water delegation as it involves a multidisciplinary work of professions that do not commonly work together.

We took an afternoon to visit a small scale agricultural producers in the area that work together in order to reduce production costs. In their case, irrigation is dependent on rainfall which makes their production vulnerable to the changes in climate. As members of the nearby small community, they explained how the community managed the water for human consumption which taught us that with good will and the right management you can secure water for those communities that don’t have a public supply utility provider. The visit proved to be very educational, and at the end the farmers were generous enough to let us try some of their delicious “tuna”, which is the fruit of the cactus that they grow.

Dr. Carlos Alberto Rubio Jimenez presented next, demonstrating the evolution of oil production management and we discussed the new energy reforms that are taking place in Mexico. Next, the observed changes in climatic factors in the last years in Guanajuato were addressed by Dr. Juan Huerta along with the impacts and possible solutions. Dr. Gina Warren talked about the oil and gas – water nexus, focusing on fracking and water use which is always a controversial topic. Dr. Warren also discussed the possible impacts that climate change could have in different energy resources available in the United States. Sadly this was her last presentation for the study abroad, and we enjoyed her class so much that we agree we would love to invite Dr. Warren teach a course in College School, discussing energy in the U.S. in terms of its production, and consumption.

During the second week we visited a lot of different buildings of UG, which are located in different places around the City. This included the “Eduardo Villaseñor Söhle” Museum of Mineralogy located in the School of Geology, which is recognized as the most important museum in Latin America with a collection of 22,000 samples. Our lectures for the week included M.S. Ricardo Sandoval who presented in depth about water issues of the State of Guanajuato, specifically the groundwater situation and measurements that are taken to conduct a more appropriately managed development of the resources. Dr. Yanmei Li explained the condition and availability of water resources in Mexico, focusing on in Guanajuato. She showed very interesting facts about the over exploitation that is occurring in some parts of Mexico, and also showed an example of a project being developed by TAMU and UG in order to have a more sustainable use of the Independent Aquifer located in Guanajuato.

We were finally starting to put the pieces together to understand water resource issues in Mexico, and we began to question the similarities and differences of issues in the United States. We listened to a presentation from Dr. Kaiser to help us create a continental perspective by covering the most important facts in the U.S. and scaling down about specifics relating to Texas. As eager learners of water resources, we started making comparisons between the two countries.

Dr. Yann René Ramos Arroyo led an excursion along the mountains outside of the City to explain the geology of Guanajuato and also discussed the mining and groundwater issues in Guanajuato. He reviewed the water quality issues caused by the mining activities; given the fact that Mexico is number one in silver production in the world. So, you can imagine the variety of issues interrelated and the considerations needed from an economic, environmental, political and social perspective.

Emilio Lacedelli Constantini spoke about food production in Guanajuato and the link between the U.S. and Mexico exportations. There was no doubt of the great opportunity that is available in the market between U.S. and Mexico; but as usual, big opportunities also mean big challenges in terms of water use and technology needed to take advantage of that benefit. Constantini’s presentation was highly linked with the visit to a local Mr. Lucky plant. Mr. Lucky is a production and packing plant of vegetables exported to the United States and the local markets. The tour of the plant lead to a better understanding of the steps involved in the huge processes of the agricultural industry.

Dr. Diana Rocha’s presentation was on water quality and public health, linking information we learned on the impact of mining and other activities in the water sources to the human health risk produced by arsenic and other contaminants in the water. It was sad to see impacts that occur when water quality is out of the adequate range for human consumption. Dr. Gilberto Carreño Aguilar also talked about water quality but focused on the different types of water treatment plants available and operation in Guanajuato. This was followed by a visit to a water treatment plant and gave us a better picture of how water is treated in the area.
The last presentation was by Dr. Lorena Eugenia Sánchez Cadena who showed us a method to improve the quality of the water extracted from the wells in Guanajuato. A practical demonstration followed, showing the development of a packed column to improve the quality of water extracted from wells.

After all the lectures were completed, the students were tasked with choosing a water resource issue and resolving several solutions to present to the group. Eleven teams were formed by a mix of UG and TAMU students. Each team was able to generate a project in a topic of their interest. We think it’s fair to say that all teams did an excellent job by explaining each problem, and by proposing some simple solutions, which could lead to a full research project in the future. The joint work from both UG and TAMU students gave an extraordinary opportunity to the participants, as they learned how to work with different disciplines and cultures to bring together alternative solutions to a variety of problems.

The course was a successful experience. We were able to learn in a classroom setting, take day excursions, and visit with local professionals. Don’t get the wrong idea, studying abroad is also about having fun, experiencing the culture, and the language, which we enjoyed as well. Having the Guanajuato students working with us was not only helpful but increased our knowledge as they showed us the best places of their home town with pride. It was a pleasure to share this experience with everybody involved, students, faculty and all the great people we meet. Gracias totales.

The Water – Energy – Food nexus is a highly important topic that is currently developing. The trip was very successful in discussing the nexus relating to Mexico and Texas, and we wanted to share what we learned through articles. We decided to make this edition of The Drop a special one, including articles related to this topic and the course. We hope that you find this edition as interesting as we do.

*We would also like to give a special shout out to Kayla Rohrbach for the wonderful photographs!
The Underreported Use and Effects of Wastewater Irrigation in Mexico

Rural communities in Mexico persist throughout the countryside, outside of urban centers and absent of any form of wastewater treatment. Over 26 million Mexican inhabitants fall within the category of a rural population, comprising approximately 22% of the country’s population. For these communities, where agriculture is an essential source of income and food production, the use of wastewater for irrigation remains a useful solution. Yet, numerous environmental and human health risks exist with the intensive use of water containing raw waste.

Smaller communities typically do not have proper waste disposal systems such as wastewater treatment plants or septic systems. Such waste tends to be deposited directly into the environment and is later used for irrigation because of the beneficial use of waste as fertilizer. Wastewater from rural communities is considered domestic waste with primary contaminants including pathogenic microorganisms, such as Cryptosporidium and roundworms. The use of wastewater for irrigation in rural Mexico and several other developing areas of the world stems from numerous factors. Some of these factors include the high cost of construction and maintenance of wastewater treatment plants, and the increasing scarcity and deterioration of water sources while the volume of wastewater continues to increase concurrently. The waste in wastewater is considered an alternative to purchasing fertilizer and provides financial savings for farmers as well. Other benefits associated with the use of wastewater for irrigation besides access to nutrients includes reusing water and therefore promoting water conservation and the year-round availability of wastewater for irrigation. During drier months, wastewater remains one of the only sources of water to irrigate land. Preventing wastewater from rural communities being released in nearby lakes and rivers assists in promoting better water quality.

While the benefits for wastewater irrigation remain a crucial element for the continued use of this alternative water source, there exist several different environmental and human health impacts from using the contaminated water. Surface and groundwater sources can be easily polluted with excess nutrients, such as phosphorus, nitrogen and pathogenic microorganisms, by surface runoff and infiltration. Soil can further accumulate contaminants affecting plant growth. Soil salinity remains a prominent issue especially in dry and arid areas. Studies have also found the excessive use of wastewater irrigation to adversely impact the quality of crops produced, such as delaying maturity of the crop. Human health concerns are a primary argument towards eliminating the use of wastewater for irrigation, as the practice poses a risk for not only the producers of the product but also the consumers. Various pathogens exist in waste, especially human waste, such as bacterial, viral, helminths and protozoa. While Mexico has adopted the WHO pathogen standards of <1,000 MPN/100 mL of E.coli in wastewater for reuse and <1 nematode eggs/liter, developing countries are not required to adopt and enforce such standards due to the concerns for adverse economic impacts. Various exposure routes for rural farmers include inhalation of contaminated aerosols from sprinkler irrigation, ingestion of contaminated food, and chronic exposure for individuals working in fields using wastewater. Consumers are susceptible to consuming food irrigated by wastewater that is not properly prepared. Neighboring communities with children playing in fields irrigated with wastewater, or exposed to contaminated aerosols are also at risk of illness.

Wastewater treatment plants have many positive aspects concerning treatment methods. They are considered a very high-rate efficient process, by which a single plant can treat a large volume of water in a short amount of time. The plants do not require a large workforce to operate. However, construction and maintenance of wastewater treatment plants are costly, causing most rural communities to not be able to fund such projects. There is also the issue of sludge disposal, both transporting it and finding a suitable location to store it without adversely affecting human and environmental health. Ecological treatment remains a much more economical solution to many rural areas hoping to treat wastewater. These treatment processes include various stages of stabilization ponds and constructed wetlands to filter harmful pathogens. Stabilization ponds permit large solids in the water to settle to the bottom of the pond before the water continues to flow to a wetland where plants and bacteria naturally filter other potentially harmful contaminants. Ecological treatment methods can only filter a smaller volume of wastewater than a wastewater treatment plant. These processes do not require electricity to operate and can be built for a lower cost than a treatment plant. Studies have also indicated that the fertilizing benefits of using wastewater for irrigation have not been determined by this filtration method.

The environmental and human health concerns stemming from wastewater irrigation in rural communities in Mexico remains a significant issue. As so many other water management dilemmas lack a defined solution, so does this one. Yet several measures can be taken to mitigate the risk of infection and detriment to humans and the environment. Such measures proposed include incentivizing rural farms to develop localized ecological treatment systems, establishing extension programs to educate rural farmers of the adverse effects of using wastewater for irrigation and further promoting the development and use of wastewater treatments plants in the country of Mexico.

There exist several management solutions available to help decrease the adverse environmental and human health effects of wastewater irrigation. Two primary remediation methods including constructing wastewater treatment plants, and small scale ecological treatment solutions. A combination of both methods can assist in promoting safer and efficient practices for using wastewater.
Irrigation practices in Guanajuato and Texas

Agriculture is one of the biggest water consumers worldwide. As our global population rises, the demand on water also increases in all sectors. Due to this added pressure, all sectors are being asked to be more efficient in their water uses. As a major water user, the agricultural industry needs to evaluate their current practices and try to decrease the amount of water wasted based on inefficiencies in irrigation.

In Guanajuato, agriculture uses 84% of the total 4.3 million acre feet of water consumed in the state. Of this amount, it is estimated that about 60% of the water is wasted due to evaporation and runoff along the edges of fields. Around a quarter of the total farmed acreage is irrigated and the rest is rain fed. The most commonly used irrigation method in Guanajuato is gravity or furrow irrigation (figure 1). This is considered to be one of the most inefficient techniques with only 40% of the water getting up-taken by the crops. Less popular irrigation methods such as drip or sprinkler irrigation, which are known to be more efficient, but also more expensive.

In Texas, agriculture is also the biggest user of water consuming close to 60% of the total 14.5 million acre feet water used annually. Similar to Guanajuato, around a quarter of total farmland is irrigated. One difference between the two states is that in Texas, the most common irrigation method is sprinkler irrigation which we can observe in figure 2. Almost 80% of all of the irrigated land uses sprinklers, while furrow is only used in 13% of the irrigated land. By using the sprinkler method, water efficiency increases up to 75% in the most optimal conditions. An interesting comparison to see is that furrow efficiency in Texas can range from 50-80% while in Guanajuato the efficiency is at most 40%.

This shows that, even using the same method, there are different procedures that can lead to a more efficient use of water. More extensive research has and continues to be examined to find the most efficient application of popular irrigation techniques. Some recommendation given by the USGS to improve furrow irrigation include: leveling the field, surge water, and capture and reuse runoff. These methods help in the overall application of water because a smaller amount of water at prearranged intervals and then any excess water can still be recollected below and then sent back through the system.

Soil management is one of the most important conservation methods when it comes to improving the irrigation efficiency in agriculture. Soil is the medium that absorbs, transmits and transports water into the crops and ground. There is a wide range of options in what a farmer can do to manipulate the quality of the soil. The best conservation technique is going to depend on the kind of soil you have. Conservation tillage, using compost and covering crops to keep the soil on the land and reduce evaporation are some examples of things that can be done. Generally, good soil practices involve keeping the soil moist and protecting it from evaporation, as well as, keep the top soil that is usually filled with good nutrients, in place.

There are also new technologies that can be used by farmers to improve their irrigation operations. Rainfall sensors can be used in fields and have the capability to turn off irrigation when rain is detected. Soil moisture sensors can also be utilized to help control the amount and timing of irrigation based on the current conditions of the soil. This information can be taken manually or the information can be sent straight to your phone, ensuring the farmers are always equipped with up to date data.

Some farmers may be inclined to set an automated irrigation schedule and let it run regardless of the weather. Which can lead to overwatering crops and wasting water, adjusting irrigation, adjusting irrigation, adjusting irrigation, adjusting irrigation, adjusting irrigation, adjusting irrigation, adjusting irrigation, adjusting irrigation, adjusting irrigation, adjusting irrigation, adjusting irrigation, adjusting irrigation, adjusting irrigation.

In Guanajuato, many farmers are starting to unite with other farmers in their area to buy tools that can be shared together to help them improve the overall efficiency of their fields. Other techniques in Texas include the introduction of more drought tolerant crops or using genetically modified crops that are made to be more drought resistant. In Guanajuato, many farmers are starting to capture rainfall. The water that is harvested can then be applied to their fields instead of drawing new water out from the aquifer.

Both Texas and Guanajuato are observing depletions of their aquifers, and limited availability of surface water, however in the US in general, there has been in the past years a tendency to reduce the amount of water consumed and at the same time the crop production continues to increase; this can be associated to better techniques, more knowledge, genetically modified crops. The idea is that states have made conservation practices more attractive and accessible to farmers. This is something we hope to continue and grow in Texas. In order to start seeing similar improvements in Guanajuato, government programs need to strengthen and provide support to their largest industry. Farmers and local farmers to determine how much water is really necessary to grow certain crops. Research looks at dryland farming, applying various amounts of water and looking at the overall output of the crops.

There are many other efforts in both Guanajuato and Texas to help give farmers the tools and knowledge to be smart water users. In both states, grants and loans are offered to farmers to help them buy and utilize new technologies that conserve more water. In Guanajuato, farmers are also starting to unite with other farmers in their area to buy tools that can be shared together to help them improve the overall efficiency of their fields. Other techniques in Texas include the introduction of more drought tolerant crops or using genetically modified crops that are made to be more drought resistant. In Guanajuato, many farmers are starting to capture rainfall. The water that is harvested can then be applied to their fields instead of drawing new water out from the aquifer.

While there are a variety of options online and on the field that can be used to improve current techniques, many challenges are still being faced. Online networks and databases rely heavily on funding and data input from various areas. This is an opportunity for universities and farmers can work on updating and maintaining the information in these areas in order to ensure that knowledge is available for those who don’t have the means to do research or buy the newest technologies. Continual research is being conducted by agencies like the USDA and other local farmers to determine how much water is really necessary to grow certain crops. Research looks at dryland farming, applying various amounts of water and looking at the overall output of the crops.

There are many other efforts in both Guanajuato and Texas to help give farmers the tools and knowledge to be smart water users. In both states, grants and loans are offered to farmers to help them buy and utilize new technologies that conserve more water. In Guanajuato, farmers are also starting to unite with other farmers in their area to buy tools that can be shared together to help them improve the overall efficiency of their fields.
Highlights from Water–energy–food (WEF) Nexus Tool 2.0: guiding integrative resource planning and decision-making

I- Introduction
The unprecedented increase in global population, the growth of middle-class societies and their increased purchasing power, climate change, economic development, international trade, health and environmental concerns, all play roles in magnifying or reducing the growing stresses on the vital resources of water, energy and food (WEF). The absence of systemic management strategies threatens the ability of these resources to meet growing demand. Projections for water availability and quality, food and energy availability, soil and air quality, among others, are alarming. These alarms point to one major conclusion: ‘business as usual’ is no longer viable. Indeed, they call for a fundamental shift in the manner in which we understand and manage resources: a shift away from traditional ‘silo’ approaches toward more integrative, systems approaches. While such a shift is promoted on multiple global stages, progress remains fragmented and tends to focus on specific, singular aspects of the nexus.

The WEF systems are highly interconnected: food production requires both water and energy; pumping, treating, and transporting water requires energy; energy production requires water (Mohtar & Daher, 2012). The three systems are also affected by forces that can exacerbate or help mitigate the stresses between them. National strategies for governing the management of one system are often developed independently of the other two systems, thus failing to consider the interconnections between the three. This often results in conflicting strategies and increased competition for the same resources. While ‘nexus’ discussions have gained thrust in policy and science arenas over the past few years, there remains a need for increased awareness and integrative planning amongst the involved entities. This need can be addressed through a quantitative framework using tools that will guide increased cooperation and integrated planning. This paper reviews the existing tools and then presents a new, scenario-based framework and tool: the WEF Nexus Tool, and in the context of its application to a case study country (Qatar).

II- Study objectives
The main objective of this paper is to introduce the WEF nexus as a platform for resolving current and foreseen bottlenecks. The platform is governed by a comprehensive framework that reflects the multidimensional, interdisciplinary nature of resource management projects. Specifically, the objectives of the paper are:
To present a scenario-based, integrated framework, and an application tool based on that framework, that offers an explicit quantification to the existent interlinkages between nexus components and affecting externalities.
To evaluate the tool’s performance through assessment of its functionality and output, and to perform sensitivity analyses on its parameters.
To demonstrate the tool’s utility as a decision-making guide in a case study for Qatar’s food security.

III- Methodology
Conceptual scenario-based framework
Figure 1 shows a generic conceptual representation of the interconnections between the water, energy and food systems. The framework starts by identifying nationally consumed food products. A portion of these products are domestically produced and consumed (DPC), while others are imported (IMP). Products could also be domestically produced and exported (DPE).

Figure 1. Block diagram demonstrating the water–energy–food nexus framework
This cost is based on market prices, which do not reflect subsidies that might be put in place to support local production. The amount of water needed (m3) for a proposed self-sufficiency scenario depends on the water requirements (WR) (m3/ton) of the type of food product grown locally. It is primarily affected by the type of agriculture and technolo...
The water needed for growing food products in open fields versus greenhouses may vary widely. WR is also highly affected by the selected irrigation method. Different sources and amounts of water are allocated for agricultural production. There is an energy cost E1 (kJ/m3) to securing water, whether through pumping (ground or surface water), desalination, treating wastewater or other.

In addition to the energy cost of securing water, energy is also required for food production processes, including tillage, harvest, fertilizer production and local transport – E2 (kJ/ha). Energy is secured through various available sources and, depending on the need and source, the carbon footprint is quantified C1 (ton CO2/kJ/m3) and C2 (ton CO2/kJ/ha). From a global perspective, energy is required to transport imported food products – EIMP (kJ/ton), and respective carbon is emitted CIMP (ton CO2/ton).

VI- Tool structure (WF Nexus Tool 2.0)

Having defined the interconnections between the three systems, this section will introduce the WF Nexus Tool structure (Figure 3) which allows for the creation and assessment of different scenarios and consists of inputs that reflect national food, water and energy strategic options. The scenario is created by the user by choosing the following:

Figure 2. Tool structure and the calculating sustainability index.

- Percentage of self-sufficiency of food products (%SS) in a selected national food basket (e.g. %SS of tomato 50%, %SS of cucumber 20%). ‘Self-sufficiency’ is used as a representation of the ratio of a specific food product produced locally to the total national consumption of the same food product.
- Percentage of food products grown in open agriculture conditions (%OpAg) (versus protected agriculture, greenhouses) for each (e.g. 30% of tomatoes produced in open conditions, while 70% of are produced in greenhouses).
- Percentages for each of the different water sources for the given scenario (e.g. 30% desalination, 70% groundwater).
- Percentages of energy sources for the scenario (e.g. 30% fuel oil, 20% wind, 50% solar).
- Percentage supplied and sources of countries for the imported food products (e.g. 30% of imported tomatoes from Jordan, 70% from Lebanon).
- Using the five scenario inputs above, and based on the local characteristics of the area under study (Figure 2), the tool assesses the given scenario by calculating the following:
  - Total water requirement for the scenario W (m3).
  - Total land requirement L (ha), based on local production and yields.
  - Local energy requirement E (kJ), split between energy needed for securing the required water (E1) and energy for local food production (E2).
  - Local carbon footprint C = (C1 + C2) (ton CO2).
  - Financial cost F (US$).
  - Energy consumed through import EIMP (kJ).
  - Carbon emission through import CIMP (ton CO2).

The ‘local characteristics’ consist of information that describes the area under study and includes yields for different food products (ton/ha), water requirements (m3/ton), energy needs (kJ/ha or kJ/m3), and other items, as listed in Figure 2. While the structure of the tool is generic, the local characteristic data are specific to the area under study and play an important role in defining the resource requirements for a given scenario.

V- Case study: results and discussions

In 2010, 41 crops were reported by the General Department for Agricultural Research & Development, Ministry of Environment as locally produced in different proportions. The analyses in the first part of this section include scenarios using the eight food products identified above; afterwards, a separate analysis of the potential of growing the staple cereals in Qatar will be discussed.

Figure 3 depicts the situation in Qatar, based on the data available in 2010. The average self-sufficiency of the eight food products is 15%. Assuming these, only tomatoes and cucumbers are produced, and protected conditions; all others are produced with open agriculture. Ground water is the main source of water for irrigation, natural gas the main source of energy and imports are primarily secured from 15 countries. The results (Figure 3) show the requirements needed for the actual 2010 scenario. Because the study is limited to eight food products, comparing a scenario’s requirements with maximum acceptable national capacities has only limited value.

The presented food products are among those currently produced and expected to have an increase in their self-sufficiency. Thus, a hypothetical self-sufficiency increase scenario for the products and an assessment of the expected resource requirements allows identification of the most critical resources when adopting decisions about increased food self-sufficiency. Each of the eight food products had a different self-sufficiency value for 2010. The graphs shown in Figures 3 represent the percentage change in the required resources resulting from an increase in the self-sufficiency of each of the products. Figure 3 shows how much more resources would be needed if the self-sufficiency of each product (tomatoes, cucumbers, water melon, green onion, lettuce, potato, eggplant and carrots) was increased by an increment of 10 percentage points (i.e. if current self-sufficiency of tomatoes is 15%, in this scenario it is raised to 25%). In this case:

The overall self-sufficiency increase is 25%. However, this 25% increase in self-sufficiency requires 82% more water, 153% more land, 82% more energy for supplying water and 97% more energy for local food production. A total of 82% more carbon will be emitted as a result of energy consumed for supplying water, and 93% more carbon emitted as a result of food production. Producing food, it is important to consider the energy needed for local food production; the outcome is similar for water, energy and carbon used for water production. Based on the preliminary projections of the study sample in Qatar, the following are possible conclusions:

- Land is the most sensitive resource requirement among the output parameters. Therefore, it is key to invest in research and consolidate efforts towards improving local yields (ton/ha). Detailed soil suitability mapping for potential food products need to be created in order to choose the optimum locations for producing the specific food products. Cultivation technologies reduce or minimize land requirements (hydroponics, more products to be grown in green house environments, etc.) should be investigated.
- Energy requirement and carbon footprint for food production rank second after land requirement. Investing in more efficient machinery for tillage, harvest and transport should be considered. (These recommendations are based on assumptions for tillage, harvest, transport and fertilizer production. When local data are collected for these items, more accurate conclusions can be derived.) Gasoline was used as a fuel for these practices. Investment in machinery that consumes less carbon-emitting fuels should be considered as a way to mitigate the increase in energy needs and carbon emissions.

Water, energy for water and respective carbon footprint

The current scenario relies on groundwater for irrigation. With the current replenishment rates in Qatar, this reliance on groundwater would
lead to catastrophic consequences. Any plan to increase food self-sufficiency should be supported by the ideas listed below:

- Create a plan for investing less water by demanding new technologies and irrigation techniques.
- Rely on alternatives to groundwater for securing water for food production, e.g. dedicate a portion of desalinated water for this purpose. If current desalination capacities cannot hold the extra demand, investing in upgrades should be considered. Due to the direct relation between securing water, energy consumed and carbon emitted, low-energy-low-carbon-emitting options should be adopted.
- Explore potentials of different renewables to fuel the technologies needed to secure the required water.
- Assess the financial costs of investment in these new technologies to increase current capacities (not currently captured by tool).

**FLocal and FIMP**
The local financial cost of food production is the least sensitive of the other resource requirements. Any anticipated increase in financial costs needs to be properly integrated into financial planning. With increasing self-sufficiency, the financial costs of importing food products decreases. The decrease is at a lower rate than the increase of local financial costs due to the fact that imported food products are of higher QAR/ton value.

![Figure 3. Resource requirement for a 2010 scenario (input data from the Qatar National Food Security Programme – QNFSP) and percentage change in the resource requirements as a result of a 10% increment in self-sufficiency.](image)

**EIMP and CIMP**
With increasing local self-sufficiency, the energy and carbon for imports decreases.

**Most sensitive does not necessarily mean most critical!**
In the previous discussions, land was found to be the most sensitive to an increase in self-sufficiency.

That does not mean that this is the bottleneck. Having to secure 84% more water for a 10% increase in self-sufficiencies could be more critical than having to secure 153% more land for the same scenario. Defining the bottleneck depends on the foresien planning in terms of upgrading current capacities and investing in new technologies.

**What if Qatar decides to grow wheat?**
In the early 1960s, the Kingdom of Saudi Arabia started growing wheat locally. Production reach its peak in the early 1990s with 4 MMt/year (Index Mundi, 2014). That practice consumed great quantities of ground water resources, most of which were non-renewable. In developing a food security plan, wheat has significant strategic importance among the staple cereals. According to UN Comtrade (2014), around 400 000 tons of wheat were imported into Qatar in 2010. Based on the previous analysis for base year 2010 for the eight food products, while keeping all self-sufficiencies the same, the following analysis measures the percentage change in resource needs after introducing a local production of 10% of the consumed wheat.

The amount of water needed would increase by 614%. Energy for water and respective carbon emissions will similarly increase. It is significant that land proved a less sensitive resource than water for the introduced 10% of locally produced wheat, due to the high yields in centre-pivot irrigated wheat, estimated to be 6 ton/ha (International Maize and Wheat Improvement Center, 2014). Nevertheless, this analysis further demonstrates the amount of additional resources needed for such a decision within a food security strategy.

**VI- Conclusions**
Water, energy and food are highly interconnected and their interlinkages need to be reflected in the planning and decision-making landscapes governing the management of these resources. Defining local sustainibility through input from involved stakeholders, as well as from the scientific and policy-making arenas, is key to proper planning and management. This paper presented a framework for a tool that reflects the interconnectedness of these core resources. The demonstrated tool is dynamical. It offers an assessment of the resource demands for different scenarios that could be used as a foundation for enforcing new guided management strategies. The tool also offers a platform structured to bring together input from science and policy-making to converge toward set goals. Further work needs to be done to improve the existing functions within the framework, as well as on building the ability to create scenarios that are energy and water focused. Modifications to the framework and tool would then be made in response to specific critical questions the user needs to answer.

Based on the Qatar case study, land is highly sensitive to variations of food self-sufficiency scenarios, as are water, energy and others. Special focus needs to be directed towards improving yields of locally produced food products, as well as investing in research for crops most suitable for growth in dry areas. Such approaches might not be the most economically viable when compared with entirely relying on imports instead, but would be attractive in the sense of providing additional security in the broader sense.

Greater emphasis needs to be made on developing robust trade strategies to cover the main country food needs. Identifying countries of low risk (in terms of ability to maintain export, low health hazard risk, etc.) and diversifying the sources of import per food product are also important elements of such strategy. The WEF Nexus Tool 2.0 and WEF framework provide a first building block that needs to continue evolving in order to provide better the needed analytics for such complex questions involving systems that are tightly interconnected and highly dynamic in a non-stationary world of constantly changing externalities.

**References**


By: BASSEL DAHER AND RABI MOHTAR

If you have comments or questions, or if you would like to submit an article, please email us at TheDrop.WMHS@gmail.com.
Illegal Tapping of Oil Pipelines: An Economic, Social, and Environmental Problem

Mexico and the United States face many of the same challenges and problems when it comes to water and energy resources. However, Mexico faces an economic, social and environmental problem that is foreign to the United States, the illegal tapping of oil pipelines or “tomas clandestinas” as it is known in Mexico. Illegal tapping of oil pipelines is when the pipeline has oil or gasoline siphoned from it without the approval of PEMEX, the state owned oil company of Mexico. The process by which the tap is placed can result in economic losses and contamination of land and water resources.

In 2000 PEMEX reported 155 illegal taps and by 2013 the number had risen to 2,614 illegal taps. From 2012 to 2013 there was a 50.2% increase in the number of illegal taps and from 2013 to 2014 a 39.9% increase. While the illegal tapping occurs anywhere there is an oil pipeline the highest occurrence is in Northern Mexico in the state of Tamaulipas. However, in 2014 the state of Guanajuato was reported to have had the 2nd highest number of taps in the country.

An Economic Problem
Illegal tapping of oil pipelines presents itself as a social problem. There are two questions that need to be asked (1) Who is stealing the oil from pipeline? (2) Why are they doing it? The answer to the former is organized crime rings and the public. The answer to the second question is because it’s a money maker and there is a need of cheap gasoline in Mexico.

In the beginning it started as small crime rings with corrupt PEMEX employees. Since then the crime has exploded and now organized crime is the main culprit of tapping and stealing oil and gas from the pipelines. Specifically, Mexican Cartels such as the Los Zetas. This cartel has a strong hold in states in Northern Mexico like Tamaulipas, where the highest number of taps occur. However, these organized crime rings would not be nearly as successful as they are if it weren’t for the help from corrupt PEMEX workers.

A Social Problem
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In the case of the Mexican Government and PEMEX the loss of oil and gasoline from pipeline tappers. In 2015 there was a bill to make penalties stronger (35 years in prison and a fine of 1,000 to 12,000 days of minimum wage). PEMEX wants the government to make stronger penalties for oil and pipeline tappers. In 2015 there was a bill to make penalties stronger (35 years in prison and a fine of 1,000 to 12,000 days of minimum wage). PEMEX wants the government to make stronger penalties for oil and pipeline tappers. In 2015 there was a bill to make penalties stronger (35 years in prison and a fine of 1,000 to 12,000 days of minimum wage).

Oil tapping can lead to oil spills which can result in water contamination, environmental degradation, harm or death to wildlife or endanger the public’s safety and health. In San Martin Texmelucan there was a tapping event that resulted in an explosion the killed 30 people. In the last few years there have been major oil spills in the city of Tabasco on and on the San Juan River that have contaminated rivers and threatened water supplies.

The Tabasco Oil Spill contaminated the Teapa, Sierra and Grijalva rivers. Initially, the spill was believed to leave up to 500,000 people without water when 5 water treatment plants were shut down. Shortly after the spill 2 of the plants reopened leaving 100,000 people without water. The government told the people to ration water and thirteen tanker trucks carrying water were brought in. In addition to affecting drinking water, the spill affected cultivated land and pasture land.

In the state of Nuevo Leon, an oil spill in 2014 contaminated the San Juan River. The river in the contaminated area is primarily used for agricultural irrigation. This affected the farmers in the areas ability to properly irrigate their crops while the river was contaminated. There were approximately 4,000 barrels of oil spilled into the river. Ultimately, the contamination plume covered a thirteen mile stretch of the river, however initially prior to containment of the plume a public water supply supply 30 miles down stream was in danger of contamination.

It becomes expensive to clean up contaminated rivers and can have a negative impact on human health. Many of the illegal taps occur in remote areas and if a spill occurs in a remote area it has the potential to spread and lead to widespread contamination. In the case of Tabasco civilians just happened to notice the oil sheen on the river and called it in.

Stopping and preventing illegal tapping of oil pipelines from occurring is of the utmost importance as it has social, economic and environmental implications. As Benjamin Franklin said, “An ounce of prevention is worth a pound of cure.” By preventing the tapping the occurrence of oil spills contaminating water resources as a result of a tap gone wrong can be stopped from ever occurring.

Solutions
As tapping oil pipelines is such a widespread and complex problem it is not easy to pin point just how to stop illegal tapping from occurring. There are a few ways in which it could be curbed, governmental changes, such as, privatization or penalties (jail time), pipeline relocation or mitigation by PEMEX.

Governmental privatization of the Mexican Oil company PEMEX is one way in which illegal tapping could be diminished. The 2013-2014 Mexican Reform has opened PEMEX up to privatization for oil and gas exploration and the first contracts were to be opened in 2015. By privatizing the Mexican oil industry it could enable better technological practices, security practices and increase the amount of money for security of oil transport. By privatizing it could also potentially reduce the corruption within PEMEX.

The Mexican judicial system does not have a good track record with sentencing of crimes and there is a high distrust of the judicial system. PEMEX wants the government to make stronger penalties for oil and pipeline tappers. In 2015 there was a bill to make penalties stronger (35 years), but it was rejected as they deemed such a sentence to be inhumane. In the Mexican Constitution, penalties for workers of PEMEX and public servants convicted of illegally tapping oil pipelines is 18 years in prison and a fine of 1,000 to 12,000 days of minimum wage.

However, a major problem with implementing penalties is the government has a hard time finding and proving a person or group stole from the pipeline. There are also questions about efficacy, as far as the cartels go, is it worth stealing the oil and potentially going to jail or to not do the crime and face the wrath of the crime ring.

PEMEX can also take measures to prevent illegal tapping of its pipelines. It can do this by increasing or introducing more monitoring along the pipeline systems. It could also contract outside companies to improve efficiency and security. In 2015 PEMEX has made changes to the way in which it ships product through its pipelines to prevent illegal tapping.

BY KATIE ASTON AND JASON MURRAY

If you have comments or questions, or if you would like to submit an article, please email us at TheDrop.WMHS@gmail.com.
Illegal Pumping cont. from previous page

PEMEX previously shipped usable refined gasoline through its pipelines. They are now shipping unrefined gasoline with the hopes that the gasoline will be harder to sell as it is not usable in cars and refineries. However, they admit that there is corruption within PEMEX so these changes will not eradicate stealing of gasoline from pipelines.

Conclusion

In the fight against illegal tapping of oil and gas pipelines there have been many failed counter measures. These measures range from enlist- ing the Mexican Army to patrol the pipelines to an anonymous tip hot- line. Although the number of illegal taps continued to rapidly grow in spite of the countermeasures enacted, perhaps they did play some role in slowing the growth. At the end of the day there is no one way to stop and eradicate illegal tapping of pipelines as the social and economic dynamics at play in Mexico will need to change. It is believed the best way to solve this problem is to use privatization, governmental reform, penalties and more as a complementary measures to eradicate illegal tapping of pipelines and the hazards it brings.

The Zapotillo Dam: Conflict Resolution in Dam Construction

In the state of Jalisco, Mexico, a dam is currently under construction on the Verde River, slated for completion later this year. The dam and re- sulting reservoir will allow for the transfer of 120 million cubic meters of water from the Verde River Basin to the overexploited Lerma River Basin. This will provide drinking water for parts of the capital City of Mexico City and ensure water supply stays in Jalisco. The main goal for the Jalisco residents is to stay on their land. The residents argue that if the Dam is built, then they will have to be relocated and suffer from various negative consequences. The residents will not only lose their homes, but also jobs, cultural and historical places, loss of community, loss of food security, loss of herita- ge, experience higher mortality rates and higher reported rates of psychological trauma. Many residents have been interviewed and voic- ed their concerns.

Private enterprises are also considered to be stakeholders and two of the main companies involved with the construction are from Spain: Abengoa and FCC Construction. There is also one company that is from Mexico called Hermes Construction. All three companies generate eco- nomic growth in the area as they hire locals to do the work. The compa- nies’ goal is to make money; because of that reason, if the dam will gen- erate profit, it is beneficial to them for the dam to be built.

The third stakeholder is the humanitarian organizations. All of these or- ganizations are against the construction of the dam. The organizations include: Various Universities in Jalisco, Observatorio Ciudadano del Agua de Jalisco, Observador de Naciones Unidas (United Nations), Tri- bunal de los Pueblos and Tribunal Latinoamericano del Agua. All of these groups (from Jalisco) are against the project because they say it is not beneficial to them. Their goal is to protect the rights of the residents of Jalisco and ensure water supply stays in Jalisco.

One of the main conflicts over the construction of the Dam is the height of the Dam. CONAGUA wanted to raise the height of the dam to 105 meters instead of its original proposed height at 80 meters to be able to meet the water demand requirements. The communities want the Dam to be kept at its original height because then less communities will have to be relocated. Acasico and Temacapulin will have to be relocated at either height, but Palmajero would be saved from relocation if the dam is kept at 80 meters. As of August 27th, 2015 the dam is currently being kept at 80 meters, but the construction is still ongoing. The government has appealed several times in the past changing the height of the dam. The construction is projected to be finalized by the end of this year, 2015.

Another of the main conflict over the project is the legal precedence of the construction. The three affected towns got together and created a committee called: “Salvemos Temacapulin, Acasico and Palmarejo” and filed an amparo. An “amparo” is “An action for the protection of consti- tutional rights or guarantees in the face of arbitrary action by authori- ties”. The townhall got together and 98 percent of them voted against the dam. The Regional Director of CONAGUA, Raul Antonio Iglesias said the following about the situation: “It’s a tiny group of people …the results of the vote were because they brought in people who don’t live there.” And “I have instructions to negotiate until the last minute with each one of the owners, but expropriation is being studied, because we have to consider the benefits to the majority”
Zapotillo Dam cont. from previous page

The last conflict that will be discussed is the land ownership. The government owns 55 percent of the land that is being used for the construction of the dam. The residents that are being relocated are upset because they are arguing that the government is not giving them appropriate compensation. They are being uprooted and asked to leave their lives behind. The government created a new community called Talicoyune for the people to relocate to, only to have the community taken out of the plan due to inconsistencies found by the state tribunal. So as of right now, they do not have, or at least have not provided the information to the public of where they are planning on relocating these people. The locals are wanting to negotiate with the government to reach acceptable compensation for resettlement. UN Special Rapporteur Olivier De Schutter said, “These communities seem not to have been adequately consulted, and the compensation offered for the loss of their lands and livelihoods have sometimes been insufficient”.

The Bois d’Arc Dam

Another current dam construction occurring here in Texas allows us to compare the differences in the development process between the U.S. and Mexico. The Bois d’Arc Reservoir will be built on the Bois d’Arc Creek, northeast of Dallas, and the prospective water supply intended to support rapid project development in nine surrounding counties within the North Texas Municipal Water District (NTMWD). The location of the reservoir falls in an area pre-designated as a possible spot for such a project if needed. As a result, the area is much less developed than the Zapotillo reservoir footprint, with only 20 private homes and one church to be condemned. In the Environmental Impact Assessment, a rigorous document required in the permitting process and submitted to the United States Army Corps of Engineers, a documented public response shows resettlement to be fifth down on the list of concerns, behind impact to wildlife, increased tax burdens, and agricultural impacts. Fifteen of the twenty homes have been purchased by the NTMWD, and all 20 properties are required to be purchased before the project can move forward. All of the water will be used within the state of Texas, in the surrounding counties, while a significant portion of the water from the Zapotillo reservoir will be transferred out of state. The approval and initiation of the projects share the similarity of a state requested project through permits to the federal authority (the U.S. Army Corps of Engineers in the case of the Bois d’Arc). Overall, the project has gone largely uncontested.

The differences between the Zapotillo and Bois d’Arc highlight some of the major points of contention that lead to conflict in dam construction projects. Some adversity can be avoided by establishing a consistent legal framework that the entire system can work within. Excluding key stakeholders from the decision making process, such as the residents of the affected towns in Jalisco, can have a major effect. Some of the residents reported that they did not know that their homes would be flooded until the saw a report on the news. The Environmental Impact Assessment required for dam construction permits to the USACE contain several sections documenting public response, and may help to calm controversy even if the residents are still affected in the end. Further, entering negotiation with affected stakeholders and reaching acceptable terms for resettlement will also play a large role in improving support for the project.

References:


Political & Technical Solutions to Guanajuato’s Water Gap

During the study abroad trip to Guanajuato, México, students from Texas A&M and La Universidad de Guanajuato were divided into groups to look at issues related to the Water-Food-Energy Nexus in Mexico and the United States. This group looked at the current water management practices in the agricultural sector and came up with possible technical and policy solutions that could help improve the issues currently at hand.

In the state of Guanajuato, México, agriculture is big. It is a 13 billion-peso industry, currently using 83% of the groundwater pumped from its aquifers. Whereas most farmers growing for local consumption generally do so through rain-fed agriculture, commercial-scale agriculture relies on the consistent availability of underground water. Groundwater withdrawals appear to far exceed the rate at which they are recharged, resulting in over-exploitation of this precious resource.

To add to that, the United States is the largest customer of Guanajuato’s produce—the U.S. buys 90% of what farmers ship outside the state’s borders. As a result, Guanajuato exports virtual water—the water captured in the exported produce—to the tune of over 38 billion cubic feet of water annually.

There are two dominant factors are at play concerning the over-exploitation of water in Guanajuato: inefficient irrigation and uncooperative management.

Efficient Irrigation

The state’s commercial farmers often use almost twice as much water as the various crops they grow actually need. Although innovations exist that could dramatically close this gap through more efficient water application and land management, the technology is expensive and unfamiliar to those who would actually use it. Many farmers who grow products to be distributed worldwide come from families who have farmed using certain methods for generations. Often, their livelihood depends on successful crops. Convincing them to change irrigation methods they see as reliable for new approaches, such as drip irrigation or could create uncertainty, and attempts to do so are often met with resistance. Moreover, systems like drip irrigation require significant upfront investment. Even if loans were available, farmers would need assurance that the expense and time it takes to learn how to successfully implement new growing methods would not threaten their livelihood.

Political solutions cont. on next page

BY KAYLA ROHRBACH AND JESSICA FOSTER

If you have comments or questions, or if you would like to submit an article, please email us at TheDrop.WMHS@gmail.com.
Cooperative Management

The relationship between the Federal Government of México and its states regarding water management is disconnected. México’s Constitution declares all water to be national property and gives the federal government control over administering rights. A person seeking water rights must apply for a permit through the national agency that oversees them (CONAGUA), but all of the country’s permits have already been allocated. As a result, any transfers happen through a water bank, where rights flow back and forth through private transactions, with minimal to no recording requirements or oversight. Consequently, the country has a weak grasp on how much groundwater is actually available, so there is no concrete knowledge of whether or not the rights have been over-allocated. It is likely that permitted water is being withdrawn disproportionately from certain aquifers, without regard to their hydrogeological features.

The division of authority is also problematic. Although CONAGUA is responsible for monitoring aquifers in the country, budget restraints and varying political climates mean CONAGUA only employs four officials to oversee the entire state of Guanajuato. This makes processes required by the federal government to be cumbersome and slow to enact change. In the meantime, the aquifers that all users in Guanajuato need to support, domestic, agricultural, and industrial use demand immediate attention.

México does operate programs that offer to fund up to half the cost of efficiency upgrades for qualifying farmers, while another quarter could return to the farmer in the form of efficiency savings. However, these funds are limited, and the disconnect between the federal government and local farmers creates a barrier to implementing improvements at the local level.

Solutions

To avoid a “tragedy of the commons” of the shared groundwater resources, users in the state of Guanajuato should focus on local and regional cooperation. Two examples of successful cooperative arrangements are instructional. First, locals in a rural area in San Miguel de Allende developed a well share cooperative in which all users pay a certain amount into a fund that the mayor domo (the water source’s manager) uses to make repairs and improvements or to drill deeper as needed. Users elect the mayor domo, empowering him to open and close the flow to each user at a given time, accepting the limits on withdraw als as part of their strategy for managing the common source. Similarly, farmers sharing an aquifer in Colorado’s San Luis Valley agreed to contribute to a fund from which they could choose to draw, as a payment not to irrigate from the aquifer that year, or as a fee for continuing to irrigate according to their rules for how rights holders withdraw water within state boundaries. With that authority, states could subject the largest users to efficiency requirements, the state could offer rebates that reduced costs to these businesses as efficiency improved. Such flexibility enables states to manage water in keeping with their desired economic, social, and cultural outcomes.

pay for efficiency upgrades. So while requiring efficiency, the state could offer rebates that reduced costs to these businesses as efficiency improved. Such flexibility enables states to manage water in keeping with their desired economic, social, and cultural outcomes.

References


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CAMILA BASTIDAS is from Venezuela. He has a Bachelor’s degree in Engineering from Universidad Central de Venezuela in 2008. Worked in the hydrological service of his country for five years and as a professor for two years. Now is a MS student in the WMHS program with interest in surface hydrology, hydraulics and modeling.

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Congratulations!
To our students that graduated last spring and summer 2015: David Moy-er (MWM), Rafi Khurram (MS), Kirstin Hein (MS), James Hootsmans (MS), David Smith (MWM), Nicole Pearsall (MWM), Aubry Wolf (MWM), Xin Zhang (MWM), and Huijuan Cui (PhD), congratulations to all of you and we can only say we shall see you in the water field! Good luck and Gig’em!

**Youtube WMHS Program Channel!**
Take a look at our WMHS Program Channel in Youtube. It has videos from our Seminar Speakers, Field Trips, and our current WMHS 689 International Water Law Class. Much more information from the WMHS program will be uploaded soon!

Check the link and subscribe: [https://www.youtube.com/channel/UC2oQFgkXZ3Er0d_YslihtEw](https://www.youtube.com/channel/UC2oQFgkXZ3Er0d_YslihtEw)

**Join the Linked In Group ‘Texas Aggie Water Managers & Hydrologic Scientists’**
Water Program current and former students are invited to join the new LinkedIn group! ‘Texas Aggie Water Managers & Hydrologic Scientists’ is designed to be a more interactive way to facilitate better communication among us, and to explore ways to continue to improve what is already a world class graduate degree program.” If you are not a member yet, please log in (get a linked in account) and join the group. [https://www.linkedin.com/groups/Texas-Aggie-Water-Managers-Hydrologic-8225806](https://www.linkedin.com/groups/Texas-Aggie-Water-Managers-Hydrologic-8225806)

**Water Daze Poster Competition Spring 2016 coming soon**
Start preparing your water topics, selecting your partner and be ready for more information on the upcoming Water Daze for next Spring 2016. More information will follow.

**WMHS Program T-shirts!**
Want to get your WMHS t-shirt? They are 10.00 DLS each and we have all sizes. If you are interested in getting the maroon-water t-shirt, please contact Rosario at: rosario@tamu.edu.

**Want to be part of The Drop team?**
If you are interested in joining The Drop team, write an article or contribute in any way. Please write to us at: thedrop.wmhs@gmail.com or contact Rosario.

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**Texas News:**

**Texas City Leaders Tackle $28Million Water Debt**
KTBS 3  September 3, 2015
The City of Texarkana prepares to vote on the budget, and anticipates increases in water rates.

**City Audit: Austin Water Utility Could Improve Meters, Loss-Reporting Process**
KXAN  August 28, 2015
A newly released audit shows Austin Water Utility, by one industry measure, leads Texas in its management of water loss, but certain utility reporting processes are “not efficient” and inaccurate water meters need improvement.

**North Texas Water District Gets Key Permit for New Reservoir**
The Dallas Morning News July 20, 2015
A critically needed reservoir to serve the booming counties north and east of Dallas has received its water rights permit from the Texas Commission of Environmental Quality.

**Fracking Boom on UT’s West Texas Lands Linked to Spills, Air Pollution**
myStatesman  September 7, 2015
The hydraulic fracturing boom on University of Texas System lands in West Texas has polluted soil, groundwater and air, according to a report to be released Tuesday by an environmental group and a think tank.

**National News:**

**California Cuts Water Use Amid Drought**
Fox News  August 28, 2015
Officials announced that Golden State residents cut water use by 31.3 percent in July, surpassing Gov. Jerry Brown's 25 percent goal.

**Detroit Engineers Work to Provide Clean Drinking Water around the World**
The Detroit chapter of Engineers Without Borders (E.W.B) is working to help make it possible for everyone in the world to have access to clean, safe drinking water.
JASON MURRAY is from Springfield, Virginia and is currently pursuing a M.S degree in the WMHS program. He received his BS in Environmental Geoscience in 2013 from Texas A&M. His interests are in water quality impacts due to flooding.

KATIE ASTON is from Gainesville, TX. She earned her B.S in Environmental Geoscience at Texas A&M in 2014. She is currently pursuing an M.S in the WMHS program. Her interests are in groundwater contamination and remediation.

WATER FOR FUN

Crossword Puzzle
Fall 2016 Edition

ACROSS
3 A traditional Mexican dish composed of a corn or wheat tortilla folded or rolled around a filling.
7 Local hero of the city of Guanajuato.
10 Fried tortillas stuffed with fresh cheese, beans or meat, covered in a guajillo and ancho chili sauce.
12 Is a long blanket-like shawl, often brightly colored and fringed at the ends.
13 Accounts for 30% of the state’s GDP.
14 Drink is most commonly prepared by mixing tequila with a grapefruit-flavored soda and served on the rocks with a lime wedge.
15 Is a small cake made with masa and stuffed with cheese, meat or other fillings.

DOWN
1 A brand of tequila produced in Mexico.
2 The Museum is considered to have the largest collection of what in the Western Hemisphere.
4 Is a world famous arts festival in Guanajuato.
5 A moon shaped dish with filled with cheese, beans and/or meat.
6 Pod-like fruit used in spicy Mexican candy.
8 The second largest city in the state.
9 Is the best selling tequila in the world.
11 Is a traditional Mesoamerican dish made of masa, which is steamed or boiled in a leaf wrapper, filled with meats, cheeses, fruits, vegetables, chiles.

Join fellow WMHS Students
For Happy Hour starting around 5:30 on Thursdays! Contact Taylor for more info:
trow0916@gmail.com

BY VICTORIA LOPEZ

CONTRIBUTORS

JESSICA FOSTER is from Oak Cliff, TX. After earning her B.S in Journalism from Texas A&M in 2003, she practiced sustainable living and farming in the Rocky Mountains. In pursuing her Juris Doctor degree at Texas A&M School of Law, she studies how to increase individual and community self-reliance.

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**VICTORIA LOPEZ** is from Brownsville, TX. She earned her B.S in Environmental Science at the University of Texas at Brownsville in 2012. She is on her way to earning a Master’s degree with research interests in hydrogeology and transboundary water issues.

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**From Bug’s Eye to Bird’s Eye**

The seminar series highlights current ecological research across multiple scales with a view towards sustainable environmental and resource management.

- Sept 22: Panel Discussion, Dr. Robert Coullon, Dr. Forrest Fleischman, Dr. Kathleen Kavanagh, Dr. Thomas Lacher, Dr. Geogannine Moreau, Dr. Sarah Patten, and Dr. Vogel
  - The application of ecological scale across disciplines

- Sept 29: Dr. Saadat Milzahn, Ecosystem Science and Management, TAMU
  - Carbon sequestration potential of hydrothermal carbonization chern (HTC)

- Oct 6: Dr. Patrick Reiter, Institute of Renewable Natural Resources, TAMU
  - TBD

- Oct 13: Dr. Monica Paredes, Department of Integrative Biology, Oklahoma State University
  - TBD

- Oct 20: Dr. Pamela Raglin, FGGS and Arizona State University
  - TBD

- Oct 27: Dr. Michael Cox, Department of Environmental Sciences, Dartmouth College
  - TBD

- Nov 3: Dr. Charles Levin, Department of Geology, TAMU
  - TBD

- Nov 10: Dr. Jangoo Wu, School of Life Sciences & Global Institute of Sustainability, Arizona State University
  - Interdisciplinary and spatial scaling: A cross-disciplinary perspective

- Nov 17: Dr. Marty Andrews, School of Human Evolution and Social Change, Global Institute of Sustainability
  - Scaling up governance in the Anthropocene

* a social gathering at Blackwater Draw at 5:30 PM

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**TEXAS A&M UNIVERSITY FALL 2015 INTERDISCIPLINARY LECTURE SERIES**

“Science and Engineering for Sustainability”

**2015 Fall Semester - 208 Scoates Hall Presentations at 4:10 pm - Reception at 3:30**

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<td>Soil Moisture Sensing</td>
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<tr>
<td>November 4</td>
<td>Muhshim Kumar</td>
<td>Duke University</td>
<td>Hydrologic Modeling</td>
</tr>
<tr>
<td>November 11</td>
<td>Jeff Basara</td>
<td>University of Oklahoma</td>
<td>Hydrogeotechnology Monitoring</td>
</tr>
<tr>
<td>November 18</td>
<td>Ganti Murthy</td>
<td>Oregon State University</td>
<td>Biosystems Modeling</td>
</tr>
<tr>
<td>November 25</td>
<td>No Seminar</td>
<td>Thanksgiving Eve</td>
<td>Evapotranspiration</td>
</tr>
<tr>
<td>December 2</td>
<td>William Kustas</td>
<td>Hydrology and Remote Sensing Lab</td>
<td></td>
</tr>
</tbody>
</table>

**HOSTED BY:**

Biological & Agricultural Engineering Department
Water Management & Hydrologic Sciences
Get Involved! Make sure to check out some of the student organizations that affiliate with water!

1. Just 4 Water:
   **Purpose:** Just4Water is dedicated to provide self-sustainable and economic water solutions to developing nations at the village level. **Website:** https://www.facebook.com/just4water

2. Texas A&M University Student Chapter - Soil and Water Conservation Society:
   **Purpose:** The main objective of this organization shall be the development and advancement of the science and art of good land use and management and the promotion of the conservation of soil, water, air, and related renewable natural resources, including, without limitation, trees, grass, fish, wildlife, and all forms of beneficial plant and animal life, and for these purposes to employ education of the people and other appropriate means, to the end that mankind may have the use and enjoyment of these resources forever. The society will also promote a more conducive relationship between the University and the local community, to establish beneficial relationships among students of colleges in the area with this chapter, and to expand appreciation for the subject matter of conservation on the Texas A&M University campus. **Website:** http://soilandwater.tamu.edu/

3. Texas A&M University Student Chapter of the American Water Resources Association:
   **Purpose:** To provide a means of interaction, connections, conversation and services for the water resources community at Texas A & M University. **Website:** http://awra.tamu.edu/

4. The Society for Underwater Technology - Texas A&M University College Station Student Chapter:
   **Purpose:** This multi-disciplinary learned society brings together organizations and individuals with common interests in underwater technology, ocean science and offshore engineering, etc. This chapter was formed in 2013 with the goal of promoting student interests in SUT. The objectives of this organization are:
   1. Serve its members and society by uniting the disciplines dealing with underwater technologies and establishing communication channels with industries related to the society.
   2. Cross-fertilization and dissemination of ideas, experience and information between workers in academic research, applied research and technology, industry and government.
   3. Promote economic and educational usage of SUT resources to benefit the student chapter members.
   4. Further education of students, scientists and engineers to maintain high standards in underwater technology. **Website:** http://sut.tamu.edu/

If you have comments or questions, or if you would like to submit an article, please email us at TheDrop.WMHS@gmail.com.