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Yemen, Water Scarcity

Yemen

Yemen is thirsty! Over eighteen million people in Yemen don't have access to safe drinking water. That's over 55% of the population! It's not only civilians that are in need of water, Yemen's agricultural crops are suffering from a lack of water too. 32.86 million people call the 203,850 square mile country home. With a GDP of just over 28.1 billion US dollars, the average annual household income is just 2,321 US dollars. For comparison, the poverty level for a family of four in the United States is \$30,000 ¹. About 64% of Yemen's population are farmers. Each with the average farm size being about 5 acres. However, due to inconsistent rainfall washout, erosion, and depleting groundwater, it is becoming harder and harder for farmers to produce the grain needed to feed the population of Yemen. In addition to the economic and humanitarian hardships facing the residents of Yemen, the devastation of a recently ended 9 year civil war has left the Yemen government in disarray. In spite of all these hardships and competing priorities, the people of Yemen need ways to get clean water to their families and to their crops as fast as possible at affordable prices.

Water scarcity is a real issue for Yemen. According to water.fanack.com, the annual water consumption for agricultural, industrial, and domestic use is 3900 MCM/year. However, only 2500 MCM/year of water is renewed through natural sources. These figures indicate that the per capita water available in Yemen is only 8% of the 1000 m³/year/capita that is defined as the water poverty threshold.

There are several conditions that contribute to the water scarcity crisis that Yemen is facing. Yemen has a dry, hot subtropical climate ². The average rainfall is about 1.3 inches, however, there are years with little to no rain and some years with 2 to 3 inches of rain. Typically, most rain comes in the winter months. Most rainfalls are short but heavy rains.

In addition to the environmental aspects of the country, Yemen has been put under tremendous strain by a lengthy 9 year civil war between the Housiet and the Shiite rebels. The civil war has left Yemen, which is one of the poorest Arab countries, with a government that is in economic freefall (www.heritage.org). This exacerbates the issues facing the people of Yemen, making it more difficult to develop solutions for deficiencies in some of their basic needs.

Yemen has two basic types of topographies - hilly in the west and south east and flat in the remainder of the country. In the hilly regions of the west and south, the elevation can change

rapidly. These rapid elevation changes combined with the heavy downburst of rain can lead to rushing water. The rushing water can lead to issues with erosion of the country's topsoil. This in turn creates more hardships for Yemen's farmers as top soil and seed can wash away.

Besides topography, the soil makeup of Yemen is important to consider when addressing water scarcity throughout the country. There are two main land use classifications for the soil in Yemen - red soil and desert. The red soil is made up of sand, silt/organic material, and clay. Red soils are notorious for being very clay-like. Hence, the red soil of Yemen does a really good job of holding a lot of moisture. However, it can take a while for the clay-like soil to absorb moisture. While this type of soil is located closer to the hilly regions of the country, the remainder of Yemen (57%³) is mostly made up of flat, desert-like soils.

The combination of low total rainfall amounts and soil erosion in the hilly areas and more desert-like, sandy conditions in the central parts of the country present unique challenges for solving the issues of water scarcity in Yemen. In order to help improve the water scarcity situation in Yemen, one can look to a study that was conducted in Yemen's northern neighbor, Saudi Arabia. Saudi Arabia has the same type of red soil as Yemen and experiences a lot of the same challenges. In 2009, the Al Baydha project was started. It was a project created to help preserve the land in the Al Baydha region in western Saudi Arabia. The Al Baydha project had three goals it wanted to accomplish - establish a regenerative agriculture system, foster a rural economy, and create affordable housing for rural residents. The site for the project was just 90 acres located in the middle of western Saudi Arabia in the Al Baydha region at the foothills of the Hijaz Mountains. This area has a few mountains, a floodplain, and some flat ground. The system that was created by this project used materials that were reclaimed from the local area. In order to capture the rainfall in the area, they created a series of dams using boulders and mud. The result was a slowing of the water flow down the hills. This prevented soil and crop residue from washing away. In addition, it helped to hold the water long enough for the clay soil to be able to absorb the water. This reversal of the desertification helped to reclaim lands for agricultural use.

The same system could be recreated in Yemen. One of the features of the Al Baydha project is its affordability. Yemen's land in the hilly areas already has large rocks, boulders, and soil that could be used to construct the same kind of system of earthen dams. Once the rain water is captured, it can be directed to agricultural lands through a series of trenches and used in crop production much like the Al Baydha project used the captured water to grow native grasses in desert areas. Besides the benefit of capturing water, the series of dams and appropriately placed water channels can help to slow flood waters and reduce erosion. Additionally, the areas in the hills that are used to capture the flooded water and to deliver the water to nearby crop areas will benefit from the regenerative environment and could provide additional grazing areas for

animals. By implementing this system of water economical rainwater collection systems, an affordable way to irrigate the surrounding cropland will be introduced to the Yemen people.

While the earthen dams of the Al Baydha project can help with agricultural water sources in the mountains of Yemen, the flat ground of Yemen is less suited to aqueducts or some sort of system to collect rainwater. Most of the population living in the flat lands of central and eastern Yemen can only rely on groundwater as their only source of safe drinking water. However, due to the inconsistent rainfall and the land's inability to effectively absorb the little rainfall that does occur, the groundwater is becoming depleted making it less and less of a reliable source of drinking water. One possible solution is to collect rainwater from the roofs of houses and other buildings. By installing rain gutters and a system to allow water to collect into rain barrels, the water could be used for non-human consumption needs or could be conditioned to provide safe drinking water for residents of central Yemen. Additionally, the captured water could be used in non-consumption applications such as watering plants or cleaning clothes. This would conserve groundwater to be used for consumption purposes.

In addition to capturing rain water to help with both agricultural and human consumption needs, there are other methods to improve the amount of water available to the Yemen population. Yemen is surrounded on two sides by the Red Sea and the Gulf of Aden. Unfortunately, that water is salt water. While it provides ample opportunities for capturing seafood, the water is not usable for consumption due to the salt content. Yemen. One way to make the water usable is through desalination plants. Desalination plants remove salt and minerals from salt water to make safe fresh water for human consumption or irrigation (copper.org). While effective at converting salt water to fresh water, desalinization comes at a high price per gallon. Yemen currently has two traditional desalination plants. With the poor economy of Yemen, the country needs a cheaper alternative to produce fresh water. One method for this production could be the use of solar powered desalination facilities. The issue with solar powered desalination comes from salt deposits that occur during the desalination process. The salt deposits can make the system less efficient. In 2022, researchers at MIT and China developed an improved desalination process that addressed the salt deposit issue. Their breakthrough in solar powered desalination will make efficient solar powered desalination plants possible. This would be an excellent choice for Yemen as it will greatly reduce the cost per gallon of desalinated water. (news.mit.edu)

While providing different sources of safe drinking water and agricultural water can be a significant improvement in improving the water shortage issues in Yemen, another step could be in the re-allocation of Yemen's crop land to different crops. Yemen has a huge khat addiction. Khat is a plant that gives a mild high and can give the user a feeling of being less hungry and make them feel as if they have extra strength. Khat itself isn't a dangerous drug and it's perfectly safe to use. The agricultural and water security issue with khat is the increasing amount of khat

consumption and the land and water resources that are used to produce it. About 15% of all agricultural ground in Yemen is used for the production of khat. However, this requires 30% of Yemen's ground water for the production of khat. Khat is using up many agricultural resources.

Why not simply convert the land use from khat to food production? In Yemen, Khat is looked at as a health drug. It is used in many ceremonies and typically served after lunch or supper. In fact, khat is used so much that it is estimated that about half of all income per household is used just for the purchase of khat. With such a high percentage of incomes being devoted to khat, it is a lucrative choice for many farmers to produce and sell it.

So how can the production of khat be lowered if it is so rooted in society? The majority of farmers produce khat because it generates more revenue per acre than other crops. The Yemen government could follow a similar idea to the United States's Conservation Reserve Program (CRP). The United States CRP is a program that farmers can sign up for to convert land they use for agricultural practices to a reserve for natural wildlife. However, instead of requiring farmers to turn land into reserves for natural wildlife, they could be required to plant food producing plants on their land to be eligible for the program. The government in turn could provide tax breaks for farmers in the program instead of furnishing them a paycheck since the government is poor. While Yemen in the past has had mediocre agricultural subsidies in the past, the government could develop a subsidy program that would encourage farmers to produce food crops instead of khat. This would divert resources, such as ground water, to food production.

While CRP would be a great program to help transition fields from Khat production to others production agricultural crops. The problem remains that Khat makes more money than a lot of other crops in Yemen. How do we deter people from consuming a plant that has no beneficial nutrients but gives the user a high? We can look at the examples of prohibition and the reduction in cigarette usage in the United States for guidance.

While alcohol and Khat are not the same, the lessons of the American prohibition can still apply. During the 1920's and into the early 1930's, the US Government made the production, sale and consumption of alcohol illegal. Though it was illegal, many of America's citizens still wanted to be able to consume alcohol. Since it was not readily available, those who wanted it had to turn to criminals to get it. This gave criminals more power and money. Additionally, this led to alcohol becoming completely un-regulated. When something is illegal, it is difficult to regulate it, but when something is legal you can regulate it and exercise more control over it. Conversely, during the 1960's and up to today the US government has made smoking become less popular by placing warning labels on cigarettes, having no-smoking campaigns, and increasing taxes on cigarettes. I believe this same approach can be useful with the Khat epidemic in Yemen.

If the Yemen government started regulating Khat, there are a number of benefits for both its consumers and the government. First, the government would need to start issuing government approved licensing to Khat dispensers. This would allow the government to start standardizing

the sale and packaging of Khat. This can lead to better control over the product. Typically, when you buy Khat in Yemen today, the person selling it to you will measure out the amount of Khat you want then put it in a paper bag. This method does not allow for standards control over the product, the amount the customer receives, or the quality of the product. Additionally, this would enable the government to create a standard warning about Khat and its effects that would be required to be printed on the package. This was a move made by the US government when they were regulating cigarettes. In 1965, the US adopted a law requiring all cigarettes to be fitted with a warning label. This warning label started a stigma around cigarettes for not being healthy and helped deter some potential smokers. This warning label can educate Khat users about the dangers of using Khat – increased heart rate, mouth cancer, and tooth decay. In the long term Khat will start to get a stigma around it for not being healthy and can possibly start to deter some current users.

By bringing Khat under government regulation, Khat can then be taxed by the government. It has been shown that for every 1% increase in price, there is a 1-2% drop in the consumption. Since most of Yemeni’s people only make \$2 USD to \$3 USD a day, they are very price sensitive to changes. Khat sells for about \$10 USD or 2,503.50 Yemeni Rials for a small bag of Khat. By starting with a low tax rate, the financial burden on the purchaser is reduced (see Table 1). This keeps consumption relatively high with the government starting to raise funds from the taxes (Figure 2). As the tax rate is increased, fewer people will purchase Khat. This will reduce the overall number of people that will purchase Khat. Consider the example of adding 0.5% tax to Khat. This would cost the consumer an extra \$0.05 USD (Table 1). That same rate would lead to a yearly tax payout to the Yemen government of \$51,645,911.94 (Figure #1). With a reduced need, some of the ground can then be converted from Khat production to consumable agricultural products.

Table 1: Customer Tax on a \$10 USD bag of Khat

Customer Price with Tax				
Tax Rate	0.05%	0.10%	0.50%	1.00%
Customer Paid Taxes to Government	\$0.01	\$0.01	\$0.05	\$0.10

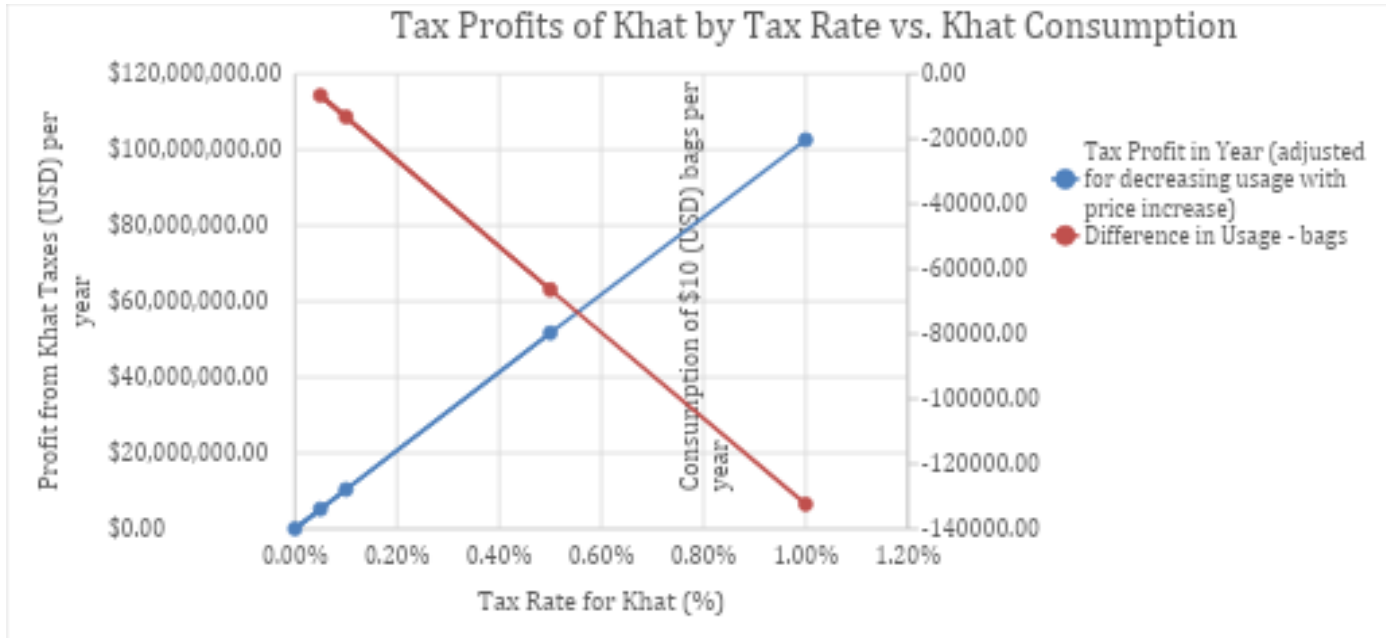


Figure 1: Tax Profits of Khat by Potential Tax Rate vs. Khat Consumption

To further the push to end Khat production the government can highlight the usage of tax payers dollars and what the taxes are going towards. For example water desalination is one solution that can help further get fresh water to Yemen residents from sea water. The typical cost of a water desalination plant ranges from \$1,000,000 USD to \$25,000,000. With a tax rate of 0.05%, the government would be able to pay for a \$25,000,000 desalination plant in about ½ a year (Figure 2). If the Yemen Government decided to build the water desalination plants, they could send out monthly reports to residents on how the plants are coming and what the affects will be to help the residents. This could also be done with roads, schools, and other forms of government infrastructure.

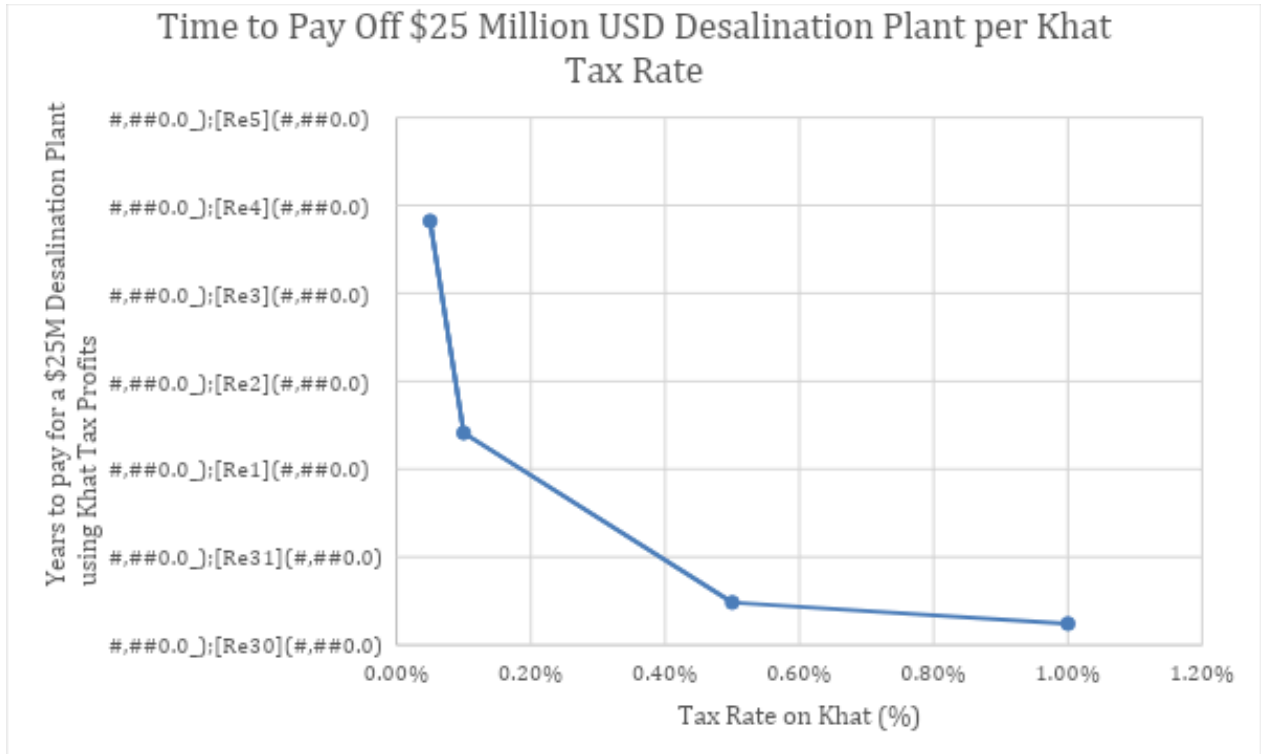


Figure 2: Time to Pay Off \$25 million USD Desalination Plant per Khat Tax Rate

Is it possible to help quench the thirst of Yemen? While the unrest of civil war has left the government in economic ruin, there are still alternatives that can be pursued on the individual level and state level to help improve the water scarcity issue. The earthen dams and associated streams shown to provide benefit in the Al Baydha project can help the elevated areas of Yemen to provide rainwater for irrigation of crops. Personal use water can be collected in rain barrels, saving groundwater for consumption. Even changes to the agricultural crops can provide improvement in water usage. Recent advances in technology can help Yemen's economically stressed government produce more affordable desalinated water. With these combinations of practices, it is possible to improve the water supply for life sustaining pursuits and to improve the quality of life for the people of Yemen.

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