Noise Reduction and Image Enhancement of War- torn Syria after The Syrian Refugee Crisis

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Abstract: The Syrian Civil War which began in 2011, led to mass migration out of the country in the years and months that followed. Most of the refugees went to neighboring Jordan, Lebanon, Iraq, Israel, and Turkey. As a result of this civil war and mass migration, the landscape of Syria changed dramatically. Land cover changed and as a result Land-Use also changed greatly. Refugee camps popped up all over the Middle East, with the majority in Jordan, Turkey, and Israel. Camp locations can be seen vaguely from Landsat imagery, but not nearly as clearly as they could be. So in this project, the main objective is to sharpen and enhance images so the refugee camp locations can be seen clearer and easier. With sharpened Landsat Imagery, we can perform a more accurate change detection of the war torn areas and refugee camp locations. Water stress was occurring in Syria the years prior to the event, and at the time the Civil War broke out in 2011. Poor governing and misuse and overreliance on irrigation worsened the country's ability to cope with the severe drought. With the mass migration that followed, water levels came back up in Syria with less people using the resources of the countries water availability. But in neighboring Jordan to the south; water levels went down as many once Syrian residents fled there. Particularly, the Yarmouk River basin shared by Jordan, Syria, and Israel, as this river is one of the main sources of water to the area. Conflict and consequent migration caused around 50% decreases in both irrigated Agriculture in Syria, and retention of winter rainfall in Syrian dams, which in turn gave rise to unexpected and unusual additional stream flow to downstream Jordan during the refugee crisis (Muller & Yoon, 2016). This phenomenon is common when populations shift quickly, and go to show that population can greatly affect land-cover for the better or worse. Large populations play a huge impact on nearby water bodies, and in this analysis we can clearly see the shift in population played a big part in altering the water in an already water stressed part of the world. Wars breaking out also can enhance water shortages in a country as more people in an area fighting on both sides places even more stress on water resources; and The Syrian Civil War and Refugee crisis that ensued because of it are a prime example.

Introduction: The conflict in Syria is the largest human rights tragedy in the 21st century, due in large part to the heavy handed and indiscriminate military actions of the Syrian government, more than half of all Syrians have been forced to flee their homes. Ongoing multi-sided armed conflict in Syria between the Ba'athist Syrian Arab republic Led by president Bashar al-Assad, along with domestic and foreign allies, and domestic and foreign forces opposing both the Syrian government and one another was the beginning of the tensions. Protests of president Assad's removal were violently suppressed; resulting in an all-out Civil war, one of the worst since the American civil war. The war, which officially began on march 15, 2011, with major unrest in both Damascus and Allepo, was being fought by several different factions: The Syrian government's Armed Forces and its international allies, a loose alliance of majorly Sunni opposition rebel groups (including the Free Syrian Army), Salafi jihadist groups (including al-Nusra Front), the mixed Kurdish-Arab Syrian Democratic Forces (SDF), and the Islamic State of Iraq and the Levant (ISIL), with a number of countries in the region and beyond being either

directly involved or providing support to one or another faction (Iran, Russia, Turkey, the United States, as well as others).

Aerial Imagery is the main way that we can view worn torn areas without setting foot on a potentially hazardous area as is the case with the Syrian Refugee Crisis and Civil War. Drones and Small-Sats can give us information about land cover, Land-Use, and water in an area and even population clusters and movement of population. This is especially useful in a phenomenon like the study in in this project as I can use Spatial Analysis tools to better visualize the mostly adverse effects that the Crisis had on the Syrian landscape. Image enhancement will be the main objective in this project with a minimal amount of cloud removal, however with the area of this particular study, this will not pose much of a problem as the climate of Syria is very Arid and Dry, and cloud cover is generally minimal, as can clearly be seen with the Landsat Imagery being used in the analysis; however, there is some cloud noise present. And to view the image clearly this needs to be removed in the analysis.

Objectives: Objectives are to obtain Landsat data of Syria for Spatial and Geographic manipulation, so as to get a view of the land area and mainly for image enhancement of the imagery to better view the refugee camps, and to get them to pop out better in the LandSat images . Main objective is to see how the Civil war and Refugee crisis changed the country of Syria both physically, politically, and financially. It's an extensive study and this project just scratches the surface of what can be done with remote sensing of such a globally infamous event in recent history.

Articles: **Digital Image Processing Literature Reviews:**

Article # 1 - Impact of the Syrian Refugee Crisis on Land Use and Transboundary Freshwater Resources

Article 1 discusses how the Yarmouk Watershed basin shared by Syria, Jordan, and Israel shrank dramatically after the 2011 Civil War and ensuing Refugee Crisis, due to a number of factors including overuse of the rivers watershed during much of the conflict period to supply the soldiers and refugees with adequate water. The article also mentions how "poor governance" and an "overreliance on irrigation" diminished the country's ability to cope with the severe drought it had been facing(and still dealing with) in recent years. The general study that the article focuses on is; the changes in Land-Use and water flows/levels due to the displacement of refugees from Syria to Jordan. Using Landsat 7 imagery, it could clearly be seen that Land-Use was altered greatly due to the migration of large amounts of population, in particular; irrigated croplands and agriculture. An interesting thing they found in the study with their Landsat imagery is that water flow and levels actually increased in Syria after the conflict and displacement of a large portion of Syria's population, but subsequently fell in neighboring Jordan as much of those Syrian refugees went there and water demand went up to accommodate this large influx of Syrian refugees. The Jordan River was also negatively affected by the migration as water levels went down over the course of the analysis/study.

Much of the material in this article is relevant to the class project of mapping and portraying how the Syrian Refugee crisis affected the land of Syria physically, politically, and economically. Water level change in an area is one of the most common ways to utilize Change Detection in the field of Remote Sensing.

Article # 2 - Monitoring urban growth and land use change detection with GIS and remote Sensing techniques in Daqahlia governorate Egypt

The study area for this published article was a region in northern Egypt known as Daqahlia. The region is experiencing a large population growth which the article refers to as the phenomenon of "Urban Sprawl," a term often used in the field and study of Geography. The main goal of the study was to show how much of this region and a lot of Egypt have seen increases in urban built up areas and a decrease in agricultural land. All this can be seen with Remote Sensing and GIS with change detection maps; which just show how the land has or is changing over time at the same location, but at different times and dates. Supervised and Unsupervised classification techniques were used in the study of the region to create graphs of the agricultural areas, urban areas, water bodies, and barren land. (Only four land cover classes were needed for this part of Egypt as the variety in land cover is small.) the study period was from 1985 to 2010, and during that time agriculture areas almost decreased by half its area by 2010, and the built up urban areas grew nearly 8 times from 1985 to 2010. Water decreased slightly and areas of barren land became more prevalent during the time period. The analysis mentioned in the article uses many of the same approaches we will do for the Class Project in that the study concerned large influxes of population over a certain time period. The study also mentioned supervised and un-supervised classification techniques to better visualize RS data a technique we also used in our study of the Syrian Refugee Crisis. And very similarly to the previous article and study area, the idea of change analysis was used; a common theme seen throughout Remotely Sensed data and analysis, to depict trends.

Article # 3 - Infrastructure Evolution Analysis Via Remote Sensing in an Urban Refugee Camp – Evidence from Za'atari

In the third article, the study is: Infrastructure change using Remote Sensing of an urban refugee camp in Za'atari, in northern Jordan. The main purpose of the study according to the article is to show how refugee camps change over time to serve their inhabitants as far as shelter, food, infrastructure and access to drinking water. Refugees in camps can sometimes be there as long as a decade and the study wants to analyze what changes happen in the refugee camps over the course of their lifespan or time of operation. The Za'atari refugee camp was used because it's the largest camp to come out of the entire refugee crisis, and Most of its residents are from my area of interest in Syria. The article mentions how little research has gone into the study and analysis or refugee camps using Remote Sensing ; so with that the papers goal was to show how remote sensing was used to see how the Za'atari refugee camp changed over time to accommodate growing numbers of refugees and supplying them with the

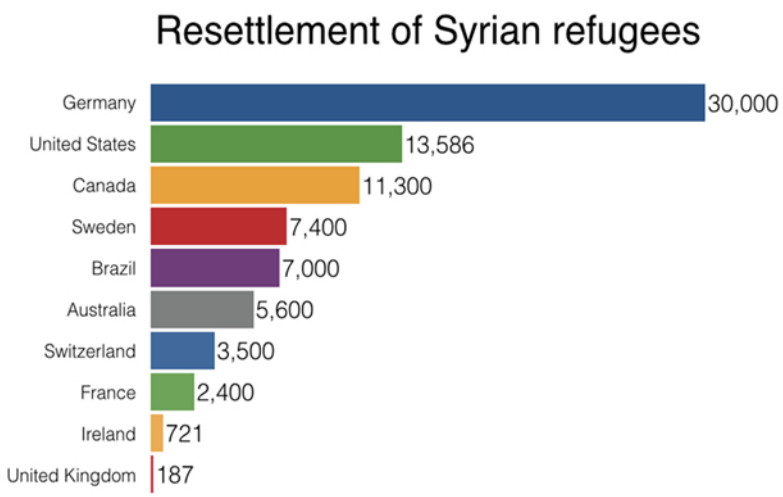
resources they need for survival. The refugee camp is considered an “urban” refugee camp which means it operates like a small city in terms of “infrastructure, electricity, water, and sanitation systems, governance and support services, and healthcare/health services”(Tomaszewski)

Methods - The analysis used many images that were donated to the research that had Multi-spectral sensor bands from the Worldview 1, 2, and 3, Quickbird 2, and Geoye 1 platforms.(Tomaszewski) Open Street Map data repository was also used, to compare with the images mentioned above. “Image differencing” was used in the analysis, which is a change detection method that is reliable and well-established in the field of Remote Sensing.

With the analysis of these images it was determined that over time refugee caravans tended to gather around and along the roads in the camps, as this was the best areas for food access. Also, refugees tended to move their caravans and tents closer to relatives and friends. A second image interpretation determined that from 2011 to 2013 the number of tents in the camp greatly increased as 2013 was the year that the majority of the refugees settled in the camp. The analysis and image interpretation was validated with actual conversations from residents in the Za’atari camp.

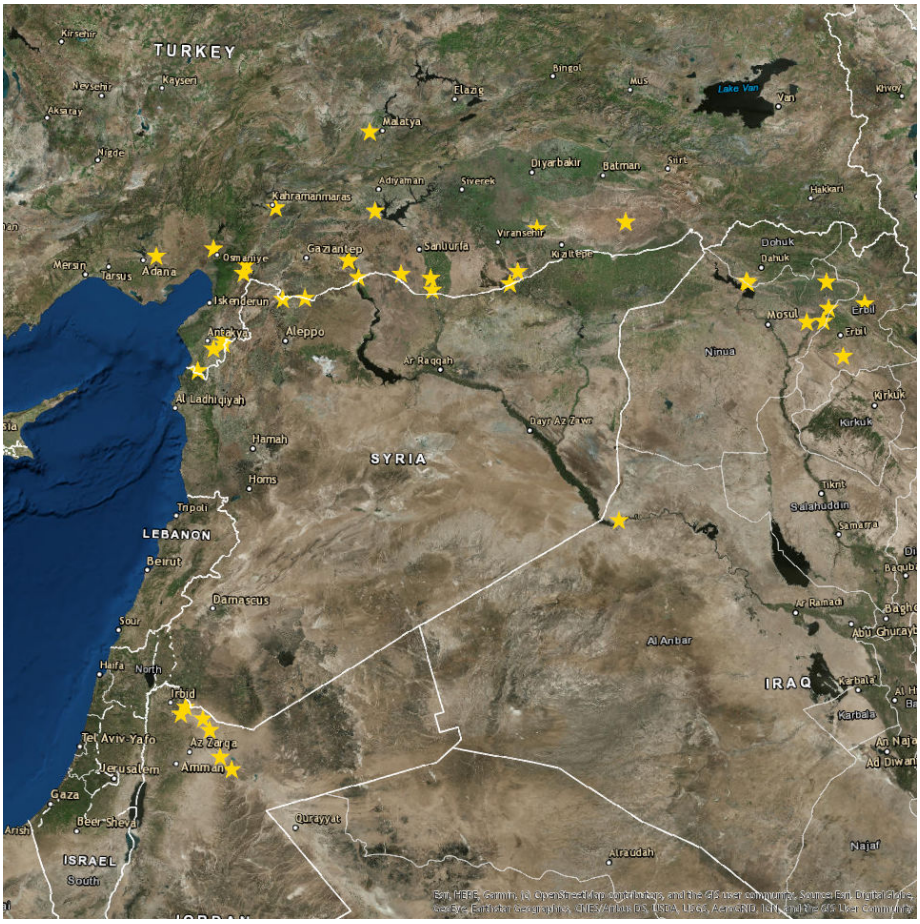
Map Products

Figure 1: Relocation of Syrian refugees outside of the Middle East:



Materials and Methods: All landsat data was obtained and downloaded from EearthExplorer.usgs.gov and all refugee camp location data was obtained from https://data.humdata.org/dataset/syria-refugee-sites the January 21 2016 data. Methods were to add all lansat data to ArcGIS Pro, and then add the cvs table for refugee camp coordinates and then display XY data for the table to get the vector points for all the refugee camps in and around the study area. My focus was on two specific camps in Eastern turkey near the border with Syria as they were the easiest to see without any image enhancement

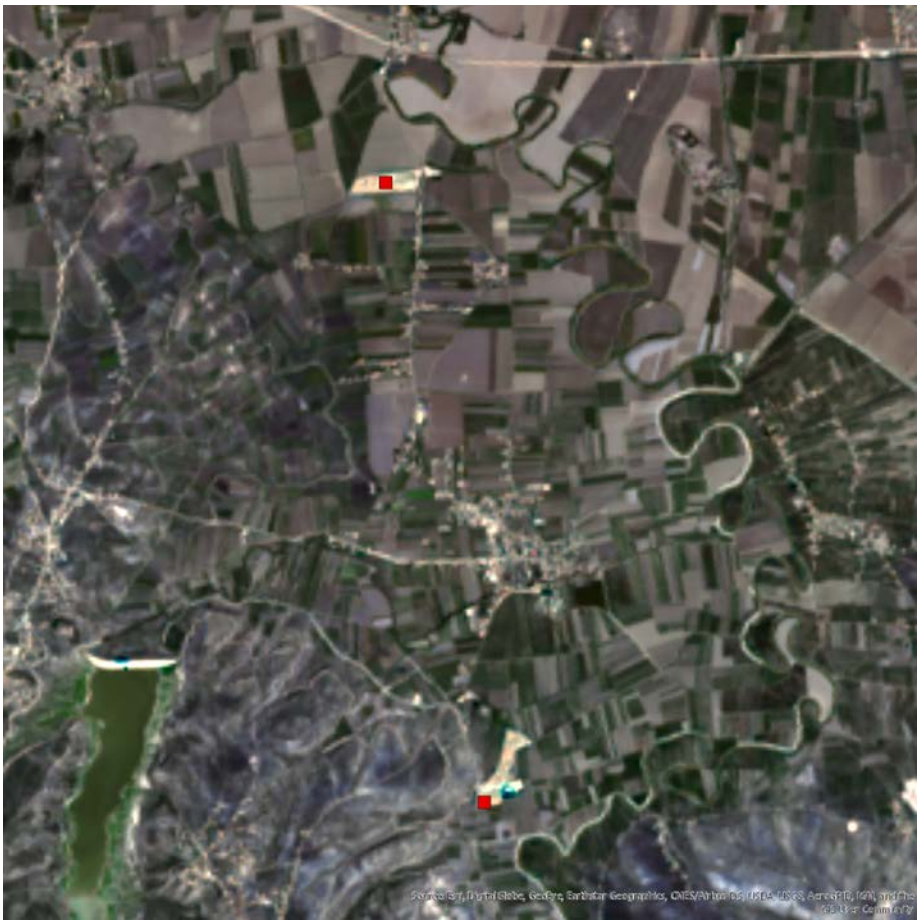
Map 1:



Location of all the refugee camps; as can be seen the majority of them are on the northern border of Syria with Turkey, but they are all officially in the country of Turkey as only there could they be out from under the oppressive Syrian regime at that time.

Two main refugee camps focused on for this particular project as they are some of the more easily seen with the Landsat 8 data obtained. Clearly we can see the lighter colored rectangles that are the refugee camps as the vector data shows as reference. The Image is fairly blurry and washed out looking so our main objective is to make it look clearer and brighter, and a better contrast via Image Enhancement.

Map 2:



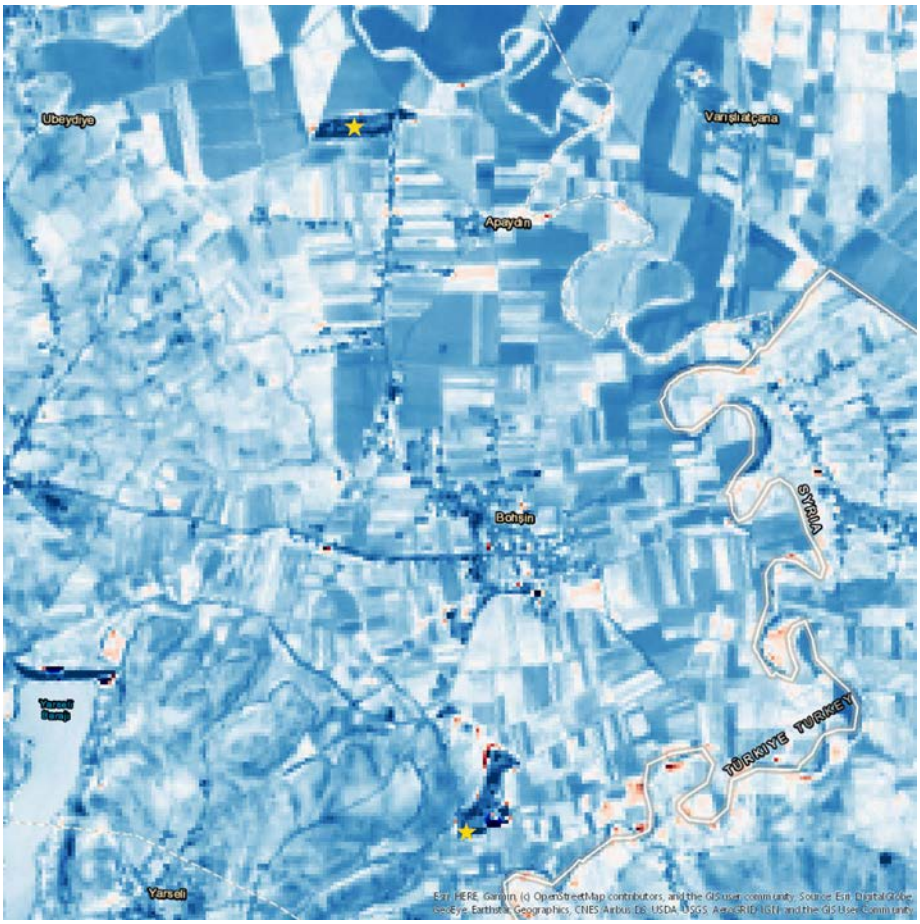
Local Enhance tool: Local contrast enhancement tool attempts to increase the appearance of large-scale light-dark transitions, similar to how sharpening with an unsharp mask increases the appearance of small-scale edges. Good local contrast gives an image it's "pop" and creates a three dimensional effect – mimicking the look naturally created by high end camera lenses. Local contrast enhancement is also useful for minimizing the effects of haze, lens flare, or the dull look made by taking a photo through a dirty window(*cambridgeincolour2005-2019*). In the

case of my Image, it makes the refugee camps pop out nicely is stark contrast so they can more easily be identified and the main objective of image enhancement is moving along nicely.

Map 3:

Log Transform: The “Log transform” tool is used to make highly skewed distributions less skewed. This can be valuable for both making patterns in the data more interpretable and for helping to meet the assumptions of inferential statistics. The Log transform is made to make patterns more visible. Here we can clearly see the darker blue denoting the refugee camps in the study. They have popped out nicely after running the log transform tool, as the different patterns in the image have become clearer and obtained more contrast.

Map 4:



Results and conclusions: Overall, I achieved what I set out to do for this project but next time I would like to start earlier so as to have more time to use more of the available tools for better and clearer image enhancement. I was able to find good Landsat imagery from Earth Explorer USGS that had the refugee camp locations in them that I needed to focus on as my area of interest. I was also able to download refugee camp vector data from humdata.org that gave me all the refugee camp data for my maps and areas of interest.

For further work on this particular project I would like to get more imagery for other locations and maybe some Imagery other than just Landsat 8. Landsat 8 was what I went with for this research as it had the most images of my area of interest in Syria. For further research on this project I would like to get some Landsat 8 Imagery for turkey to the north of Syria since that is

where the majority of the camps were located at the height of the refugee crisis in the 2013-2014 time frame. I would get an image with maybe half a dozen camps visible in it instead of just the two that I focused on for this project and run more image processing and enhancement tools to make the images look even clearer and have an overall better contrast to see how many and widespread these camps were during that time.

As of mid-2017, an estimated 260,000 refugees have returned to Syria since 2015, and more than 440,000 internationally displaced persons returned to their homes, to search for family, check on property, and in some cases, due to improved security in parts of the country, the Syrian foreign minister called on the country's refugees to return home. Nonetheless, the United Nations Refugee Agency has said that conditions still continue to be unstable, unsafe and destitute for much of the country. Improvements are uncertain, and many basic services are absent. Less than half of the returned refugees have access to health services and water due to infrastructure damage. An estimated 10% of refugees ended up as internally displaced once again.

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