Statistical Modeling of Syrian Migration Patterns

Pranav Sai Palagummi

Received June 22nd, 2022
Accepted October 3rd, 2022
Electronic access October 15th, 2022

Syrian migration has been heavily influenced by a combination of environmental and sociopolitical factors. This research paper will be centered around human migration through the employment of linear regression and coding for analysis. The structure of this research paper abides by the following format: research on the causes of migration out of Syria, and then predictions as to what changes in migration will occur if the patterns made in my data analysis continue. First, I review the environmental factors motivating Syrian migration. Next, to provide more specific context, I review the sociopolitical factors encouraging human migration in Syria. I utilize several datasets regarding internationally displaced persons, deforestation, drought-based, and tree-loss datasets. My data is gathered from two sources, the first being UN OCHA, which contains data on displaced persons and the causes for their displacement, and the second being Global Forest Watch, which contains data on deforestation. Then, I apply linear regression to analyze the relationship between key variables in these datasets. After completing my research, I determined that food and water had the heaviest impact on human migration. Finally, I discuss migration prediction, indicating possible conditions if the current driving factors continue to play a substantial role on migration in the future.

Introduction

Human migration is the singular or group movement of people from one place to another, intending to settle down in a new location for a long-term period. Reasons for migration can vary, from moving voluntarily to being forced to escape a nation due to persecution by the national government. Migration can exist, both in and out of any country, and is particularly prevalent in the US, Germany, Saudi Arabia, Russia, UK, UAE, France, Canada, Australia, and Spain[1]. However, one major hotspot for migration is Syria. Syria is known to have natural gas reserves, oil, and many more natural resources. However, people have been leaving the country as well. One primary reason for migration out of Syria is the heavy deforestation and droughts. Since the start of the Syrian Civil War in 2011, the conflict has had severe effects on the Syrian environment, causing deforestation. Additionally, a severe decrease in rainfall over the past few years has lowered water levels. The effects of deforestation and drought include a lack of crops and lower food availability[2]. Water is one of the major reasons for plant growth. Water levels and crop levels have a direct positive correlation, and when the former decreases in quantity, the latter does too. Low food availability can have various adverse effects to one's own health and environment because food is essential to life, and without it, one's life will wither away. With low food levels, our future generations will have a challenging life situation. Human migration is the key to solving this issue, being able to save thousands, if not millions of lives, legacies, and generations. However, environmental issues cannot be the only cause. Pressing socio political issues in Syria no doubt play a role in motivating migration.

To further understand human migration centered on Syria, this paper seeks to comprehensively analyze the causes of migration out of Syria and predict the state of migration in the next few decades. The rest of this paper will be organized as follows to accomplish this research goal. First, I conduct the literature review which provides necessary, in-depth context into the environmental and socio-political factors driving Syrian migration. Next, I outline the research design which highlights the datasets and methods that inform my Syrian migration analysis. Finally, I go into the depth of the results derived through mathematical concepts, allowing for a complete understanding of what exactly is happening with migration. I then talk about the future and predict future conditions.

Literature Review

Syrian migration is not simple but happens for a variety of reasons. In this literature review, I separately highlight the two major reasons understood to be motivating this migration: environmental factors and sociopolitical factors.

Environmental Factors Motivating Global and Syrian Migration

Like every natural entity in the world, human migration is affected by various things. However, a large gear behind the engine of human migration is climate change, which induces reasoning for movement through natural disasters, a decrease in natural resources, or even a reduction in snowfall. For

years, natural causes have been at play, influencing thousands of families into moving their homes, both negatively and positively[3]. Data from Olibrown even estimates the possibility of having 200 million climate refugees in the next 25 years[4].

Since the 1960s, the environment of Syria has been on a decline. Fertile lands have been getting damaged due to droughts, and crop levels have decreased by almost two-thirds since the 1960s[5]. Data from the DW reports that more than 800,000 people lost their incomes due to climate causes, and more than 85% of farmers' livestock died[5]. The environment cannot sustain life properly, and many agricultural lands have been damaged. Deforestation is also rampant in the region, with Syria losing 20.4% of all tree cover from 2012 to 2019[2]. Furthermore, the Independent writes, "The quality of the water is also decreasing so we are seeing water-borne diseases in areas in Hasakah, Raqqa and Deir ez-Zour, including in camps for the displaced," the official adds[6]. Current water levels and water quality is further negatively impacting the lives of Syrians.

An incident known as the "Syrian Food Crisis" occurred when the President of Syria decided to cut food and water aid to several Syrian cities due to monetary causes[5]. The country since then has been known as the "state on the brink of collapse." The World Food Program talks about how millions of families have been "pushed into food, hunger, and insecurity." They estimate that more than 60% of the Syrian population is under this turmoil and this has been the highest number recorded throughout history. More than 6.8 million people have been displaced due to food-related causes[7]. Furthermore, COVID-19 is also another natural process affecting Syrians. Since 2020, thousands of people have lost their homes and are fleeing to shelters outside of the country. Because of the COVID-19 pandemic, a shortage in jobs and COVID-19 testing centers, as well as a massive inflation in the economy due to the scarcity of products have occured[8].

The United Nations mentions that the Syrian government required almost 6 billion dollars in 2020 to fund the lives of all these people, but not even half of that has been met. The magnitude of this situation is so large that 2 billion dollars are not enough to sustain the Syrian refugees. Amidst the recent droughts occurring in Syrian landscapes, more than 12 million people have been predicted to be affected directly by the shortages[9]. Almost 5 million people depend on nearby village rivers, but they are all drying out, and more than 400 kilometers of agricultural land has been compromised due to droughts[10]. The rippling effects will crash through millions of lives.

Furthermore, the OCHA Services relief web service mentions that two dams that are providing more than 3 million people with electricity, are going to be closed. The rise of water-borne diseases has been rising due to water scarcity. 'The Danish Refugee Council's Middle East Regional Director Gerry Garvey said: "This water crisis will worsen. It is likely to increase conflict in an already destabilized region. There is no time to waste. We must find sustainable solutions that would guarantee water and food today and for future generations'"[10]. To this day, Syria is still at risk to many natural causes affecting its stability and the stability of its residents.

Sociopolitical Factors Motivating Syrian Migration

While environmental issues are no doubt critical to Syrian migration, focusing only on environmental issues neglects the very pressing sociopolitical issues which have impacted Syrian migration in recent years.

For instance, past research has indicated that a considerable amount of migration has been caused by political movements. These movements include but are not limited to rallies, huge decisions made by politicians, violence, and so much more. Since 2011, the Syrian refugee crisis has been inflating, with thousands of migrants leaving their homes daily, due to the civil war. Death tolls have been increasing, and the number of migrants reaching countries such as Greece and Turkey has skyrocketed[11]. It is critical to understand that many countries fail to take drastic measures to help countries like Greece and Turkey, whose migrant numbers are rising rapidly. Furthermore, a paper from the CREEOL mentions that due to the numbers of migrants rapidly increasing, especially in the past 50 years, a law was adopted in 1994, trying to regulate these levels, and prevent excess migration into Turkey and other countries[11]. They are trying to avoid the numbers of refugees and "economic migrants," indicating a growing economy's influence on migration. Economic migrants move to another place to improve their standard of life. World Vision reports indicate that about 13 million Syrians are displaced, with over 6.8 million of them registered as refugees or asylum seekers[12]. UNHCR global trends report that 1 percent of humanity has been displaced uptil now[13]. The paper from the CREEOL also mentions that the Disaster and Emergency Management Authority reported that over 200,000 migrants were living in housing centers, living off of grants, and in both tents and container cities. A policy called the "Temporary protection regulation" is a policy that allows the country to offer protection to a migrant when they return to their country, such as a refugee[11].

However, the requirement is that they can never re-enter again once the person goes back. Since 2015, there has been an estimate of over 6 million displaced people from Syria. As the paper states, "Today, the UNHCR reports 2.1 million registered Syrians in Egypt, Iraq, Jordan and Lebanon, more than 24,000 Syrian refugees registered in North Africa and 1.95 million registered Syrians in Turkey"[14]. Data has found that Syria has become less tolerable to millions of people solely because of the environment and government.

The government is a great source in terms of improving the quality of migrant life. This is because they hold the utmost power in every country. They have the power to set in place different policies and programs to aid migrants. However, many governments view the migrants that come to their countries in need of help as "sources for temporary protection"[14]. This is this kind of mindset that adds turmoil to many lives.

However, to respond to the given argument, analysis on datasets from Syria has proven that not just socio-political changes but other changes, such as food and water availability, have played a massive role in the level of migration. Food and water are integral to life, compared to any materialistic items one's government could provide. The Syrian Civil War led to a drastic decrease in natural resources, affecting how many people left the Syrian country, forcing millions out. The long-lasting negative effect continues to grow due to a lack of support from the citizens[15].

Research Design (Data gathering and specification)

The following paragraphs will detail the datasets that I will use to conduct, model, and predict levels of migration out of Syria while trying to find the most probable causes for the fluctuation levels.

Studies on the OCHA dataset will be conducted. The OCHA dataset is information collected from partner organizations and compiled by the UN Office for Humanitarian Affairs. The OCHA data file contains an abundance of information, specifically regarding IDP, which are displaced persons, along with data regarding people migrating back to Syria. Furthermore, it contains the Population, Displacement, and Return Movements in Northern Syria Humanitarian Data Exchange set. This set contains data about the levels of Syrian refugee populations and displacements, and return back to Syria. The goal is to view further data on displacement levels to be visualized.

In addition, I will use the Global Forest Watch dataset, which is combined with a dataset known as REACH. This dataset contains data on deforestation. I will input the data into an originally developed linear regression machine learning analysis to analyze, visualize, and predict levels of migration out of Syria for years to come.

I will be programming in R to complete linear modeling on how food severity, clean water availability, tree loss and deforestation, and droughts affect Syrian migration. Linear regression will be applied to the data to linearize and model the information inputted with the goal of understanding the relationship between the variables mentioned in the final 3 datasets and migration levels. Several built-in libraries will be imported, including dpyler, tidyverse, lme4, data.table, and stargazer. The point of these libraries is to open, combine, visualize, and use linear modeling on datasets.

Results and Discussion

In this section, I show that the factors with the largest impact on migration are food and water. Migration has been repeatedly affected by natural and life-driven factors rather than materialistic goods. Natural disasters include but are not limited to climate changes, tornadoes, hurricanes, or floods. Furthermore, life-driven factors include elements necessary to human life, such as water and safety. Figure 1 visualizes the impact of the following factors, food, water, non-food items, and shelter/environment, discussed earlier.

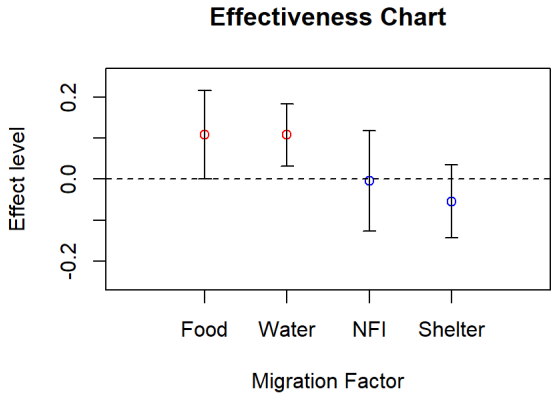

Fig. 1 This figure shows the effect of different variables on migration with error bars to show statistical significance. The figure shows the results of a linear regression estimating the effect of the lack of food, lack of water, lack of NFI, and decrease in shelter security on migration using data from the UN OCHA dataset containing information on conditions and migration. For each variable, if the standard error is large enough such that the confidence interval, the range of the two endpoints of the error bars, includes 0, then we cannot assume that they are statistically significant. By definition, this means we have to assume they are not one of the important causes for human migration out of Syria. This claim can be applied to NFI and Shelter but not to Food and Water, indicating their significance. Analysis and figures are based on data gathered from "Humanitarian needs overview Data,"[16]

As shown in Figure 1, the size of the effect in decrease of food could be right above 0; numbers ranging from 0.01-0.22. To convert these into percentages representing our population, these numbers are entered into the formula, $(e^{\beta} - 1) \times 100$, where β is our decimal number. The food effect shows a $\sim$ 1.01% decrease to a $\sim$ 24.6% decrease in population. The size of the effect in decrease of water (0.03- 0.17) shows a $\sim$ 3.05% to a $\sim$ 18.53% decrease in population. The confidence interval is 95% confidence interval. To find the confidence interval,

we multiply the standard error by 1.96. The upper and lower bounds are found by adding and subtracting the standard error multiplied by 1.96 to the estimates represented by circles in Figure 1.

Food and water are important because they make up our livelihood. Without the former or latter, we cannot survive. Shelter and NFIs are more materialistic goods, and are both realistically and statistically less significant than food and water, especially since human life is at play. In the context of the broader issues, such as the sociopolitical issues that cause a depression in the economy, leading to a decrease in food and water, it models how significant these are to migration overall. An example is a country with economical problems. These countries have a tough time providing for the needs of their citizens, affecting their livelihoods.

Food and water are important because they make up our livelihood. Without the former or latter, we cannot survive. Shelter and NFIs are more materialistic goods, and are both realistically and statistically less significant than food and water, especially since human life is at play. In the context of the broader issues, such as the sociopolitical issues that cause a depression in the economy, leading to a decrease in food and water, it models how significant these are to migration overall. An example is a country with economical problems. These countries have a tough time providing for the needs of their citizens, affecting their livelihoods.

Table 1 represents the predictions for percentage decrease in population based on data analysis from 2017-2021. The figure shows the results of a linear regression estimating the effect of Tree Loss [17] in addition to food, water, NFI, and shelter security using data from the UN OCHA dataset containing information on conditions and migration, and the Global Forest Watch Dataset containing information on deforestation in Syria. The percentages were calculated by running a linear regression on the natural log difference of the populations in Syria. Then this was applied to the different categories in the UN OCHA Dataset: Food, WASH, NFI, Shelter, and tree. From there, I had four different effects on migration, but I needed to add deforestation. In order to calculate that, I merged the UN OCHA Dataset and the Global Forest Watch set to get a new merged set. I then centered and scaled the merged dataset, and picked out the "tree_loss" category of the data. Finally, I ran a linear modeling code segment which applied our population difference variable to all the 5 effects: food, WASH, NFI, Shelter Security, and tree loss, to create Column 1. Then, a linear modeling code segment was applied to create Column 2, which shows the effects of tree loss on the factors. In other words, Column 1 shows the regression which I visualize in Figure 1 (the effectiveness chart). Column 2 then includes the tree loss. As explained in the image by Column 1, if we were to look at the log population effects, lower food levels call for a $\sim 11\%$ decrease in the people in Syria, while water availability, known as WASH, causes a $\sim 11\%$ decrease. NFI, which are non-food items, as well as Shelter Severity are not statistically significant since they go below 0. Since the effect levels are below 0, we have to assume they are not important causes for migration out of Syria based on the current data.

Table 1 Table showing the factors influencing migration [left], and how much percentage difference in population is expected [Column 1]. "Observations" calls for how much data has been observed. R^2 and Adjusted R^2 call for how much variance the population has on each independent variable. The standard error comes from Figure 1. Column 2 factors in the increase of tree loss and deforestation and the resulting effects it has on the factors [left]. Analysis and figures are based on data gathered from "Humanitarian needs overview Data," [16]

	Dependent variable:	
	Log Population Change	
	(1)	(2)
Food severity	0.108**	0.115*
	(0.055)	(0.061)
WASH severity	0.108***	0.106**
	(0.039)	(0.043)
NFI severity	-0.005	0.006
	(0.063)	(0.070)
Shelter severity	-0.054	-0.058
	(0.045)	(0.049)
Tree Loss (kha)		0.011
		(0.033)
Constant	-0.572**	-0.605**
	(0.221)	(0.248)
Observations	261	237
R^2	0.043	0.040
Adjusted R^2	0.028	0.019
Resdiaul Std. Error	0.449 (df=256)	0.469 (df=231)
F Statistic	2.884** (df=4; 256)	1.914* (df=5; 231)

Note: *p<0.1; **p<0.05; ***p<0.01

Finally, for an increase in tree loss and deforestation, there is a $\sim 1.1\%$ decrease in population over a few years, though the result is not statistically significant. Figure 2 is different from Figure 1 because we add tree loss which makes the estimate for food scarcity and WASH change to 0.061 and 0.043. The tree loss factor is not statistically significant, indicating that we need a better way to measure deforestation and climate change factors. To change the obtained percentages above from log population to population, the numbers have to un-

dergo the transformation $(e^{\beta} - 1) \times 100$, where β is our decimal value obtained from the regression. So, the $\sim 0.108\%$ for food will be $\sim 11\%$ and the $\sim 0.108\%$ for WASH is $\sim 11\%$. This transformation can be completed because we have a log outcome with non-log independent variables. We have to use the above equation to interpret them as percentages of population rather than of log population.

We can conclude that the effect of higher food and security on migration is statistically significant. We would expect that because when people cannot get food, they are likely to migrate out of Syria. Moving forward, we would expect climate change to decrease crops in Syria. As the FS Cluster organization mentions, since 1980, periodic droughts have affected the citizens of Syria, preventing agricultural growth and causing migration out of Syrian cities. Furthermore, the source indicated that between the years 2010 and 2020, droughts had caused more than a $\sim 25\%$ decline in areas that are being harvested for crops. As climate change makes drought worse, more people will be leaving. Rainfall is a vital part of clean water availability. Future work could quantify decreases in rainfall in specific areas and that to the regression model.

The future of migration

The Brookings Institution mentions that there could be approximately 143 million climate refugees coming from areas in Syria and the nearby regions[18]. These numbers are highly significant because it puts millions of people at risk and their future generations and children at risk. They cannot carry on legacies and keep traditions alive. As seen in Figure 2, our research indicates a $\sim 11\%$ percentage decrease prediction due to Food availability and a $\sim 11\%$ percentage decrease prediction due to WASH, or Water Availability. Syria currently has a population of 16.43 million people[19]. If the humanitarian crisis that is happening in Syria continues, I imagine the numbers affecting this large population will be far higher due to violence as well. The magnitude of these numbers globally affects the economy and lifestyle of the Syrian country. A country needs its citizens to thrive, workers to keep its economy up, doctors to run the hospitals, scientists to do research, farmers to help with agriculture. With millions of people moving and populations decreasing after many years, the Syrian country is globally at risk.

Conclusion

In this paper, first I spoke about factors that impact migration and why I believe these factors have a large impact on migration. In the second portion of the paper, I used data from "OCHA" and other datasets to support my conclusions of the importance of different factors and show what factors have a large impact on migration. In conclusion, future research must be able to correlate different areas' levels of rainfall levels over decades. Future researchers should research this because rainwater has a significant impact on the levels of clean water access and affects how someone moves from one country to another. Furthermore, thousands of datasets can be applied to the linear model to increase the sample space. Methods of data collection include scholarly website research and data collection through interviews.

References

1 *Immigration by Country 2022*, https://worldpopulationreview.com/country-rankings/immigration-by-country.
2 R. Gaafar, *Arab Reform Initiative*, 2021.
3 *Science for Environment Policy*, https://environment.ec.europa.eu/research-and-innovation/science-environment-policy_en.
4 O. Brown, *Migration and climate change*, United Nations, 2008.
5 *How climate change paved the way to war in Syria*, https://www.dw.com/en/how-climate-change-paved-the-way-to-war-in-syria/a-56711650.
6 *Half of Syria has been displaced by war. Now record drought threatens millions more*, https://www.independent.co.uk/climate-change/news/syria-drought-climate-change-civil-war-isis-b1947711.html.
7 *Crisis in Syria.*, https://www.wfpusa.org/countries/syria/.
8 *The facts: What you need to know about the Syria crisis*, https://www.mercycorps.org/blog/quick-facts-syria-crisis.
9 *Syria Emergency: World Food Programme.*, https://www.wfp.org/emergencies/syria-emergency.
10 *Water crisis and drought threaten more than 12 million in Syria and Iraq*, https://reliefweb.int/report/syrian-arab-republic/water-crisis-and-drought-threaten-more-12-million-syria-and-i
11 Y. Civelek *et al.*, *Turkey's Syrians: Today and Tomorrow*, Transnational Press London, 2017, pp. 23–44.
12 *Syrian Refugee Crisis: Facts, Faqs, and How to Help.*, https://www.worldvision.org/refugees-news-stories/syrian-refugee-crisis-facts.
13 *1 per cent of humanity displaced: UNHCR Global Trends report*, https://www.unhcr.org/news/press/2020/6/5ee9db2e4/1-cent-humanity-displaced-unhcr-global-trends-report.html.
14 P. Yazgan, D. E. Utku and I. Sirkeci, *Syrian crisis and migration*, 2015.
15 *Climate Change and Migration: the Case of Syria.*, https://www.wur.nl/upload_mm/c/d/e/d2328c52-f97b-4cc0-9ef0-ca458e14ae6b_Climate%20change%20and%20migration%20the%20case%20of%20Syria.pdf.
16 *Syrian Arab Republic: Humanitarian Needs Overview*, https://data.humdata.org/dataset/syrian-arab-republic-humanitarian-needs-overview.
17 *Deforestation Data*, https://www.globalforestwatch.org/dashboards/country/SYR/.
18 *The climate crisis, migration, and refugees.*,

https://www.brookings.edu/research/the-climate-crisis-migration-and-refugees/.
19 *Syria Population*, https://tradingeconomics.com/syria/population#:~:text=Population%20in%20Syria%20is%20expected,according%20to%20our%20econometric%20models.

