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Geospatial Environmental Assessment of Refugees' vulnerability and impact on the water-energy-food-health-climate nexus: examples from the Syria – Lebanon case

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PERN Cyber seminar on Refugee and internally displaced populations, environmental impacts and climate risks
10 -18 May 2021

1. Introduction

The Syrian conflict started in March 2011. The war has caused the displacement of millions of Syrians from their homes, both internally and to neighboring countries. Lebanon, a country with a fragile political, economic, and environmental landscape, has accepted to host more than 1.5 million of Syrian refugees, which is roughly more than 1/3 of its population[1]. Accordingly, Lebanon now hosts the highest number of refugees per capita worldwide (3:10), as well as per geographic area (150 per km^2), more than one third of which are living in informal settlements.

2. Water Stress implications

The urgent humanitarian crisis has caused interventions to focus on the socio-economic components in comparison to environmental and climate hazard ones. In the 1960s, Lebanon's available water per capita was 2500 m^3, given its then relatively low population and abundant rainfall compared to other countries in the Middle East (an average of 800 mm). Following a long civil war (1975-1992), the population of Lebanon almost doubled in 30 years, up to 4.9 million from 2.5 million by the early 1980s[2]. With a warming climate and less snowfall, the per capita water availability dropped to less than 1000 m^3 right before the Syrian conflict in 2011. Figure 1 shows a time series of a GIS and remote sensing based assessment of the available water in Lebanon. Refugees are mostly located in the red zones (i.e. zones where water use exceeds precipitation). The sudden influx of more than 1.5 million refugees put a high pressure on the fragile environmental infrastructure in a country that ranks eighth[3] on the world's perception corruption list. Currently, the World Bank estimates the population in Lebanon to be at 6.8 million, which brings down the total renewable fresh water availability to less than 660 m^3/capita/yr [4], close to the absolute water scarcity level of 500. This figure masks hotspots of much worse water scarcity level when the analysis is performed spatially (Figure 2).

[1] (H. Jaafar, Ahmad, Holtmeier, & King-Okumu, 2020)
[2] https://data.worldbank.org/indicator/SP.POP.TOTL?locations=LB
[3] https://www.usnews.com/news/best-countries/articles/10-most-corrupt-countries-ranked-by-perception?slide=4
[4] http://www.fao.org/aquastat/statistics/query/index.html;jsessionid=81BCA98739046E91E60CB86645E8C738

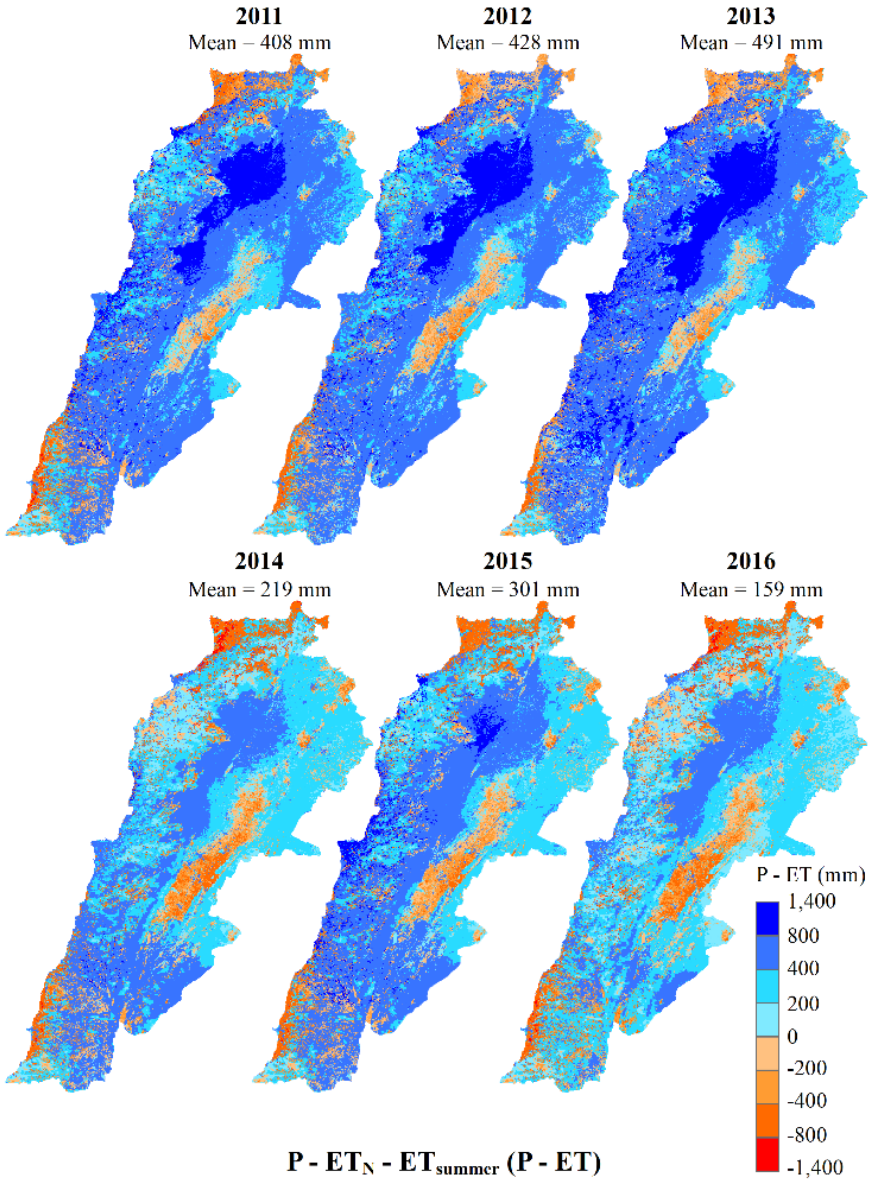

Figure 1. Spatial distribution of net available water in Lebanon since the beginning of the Syrian Crisis. P is precipitation, ET_N is winter natural evapotranspiration, ET_{summer} is summer evapotranspiration. North and South Coastal areas as well as the inland Bekaa Valley, in which most of the refugees are located, all suffer from water stress even in wet years.

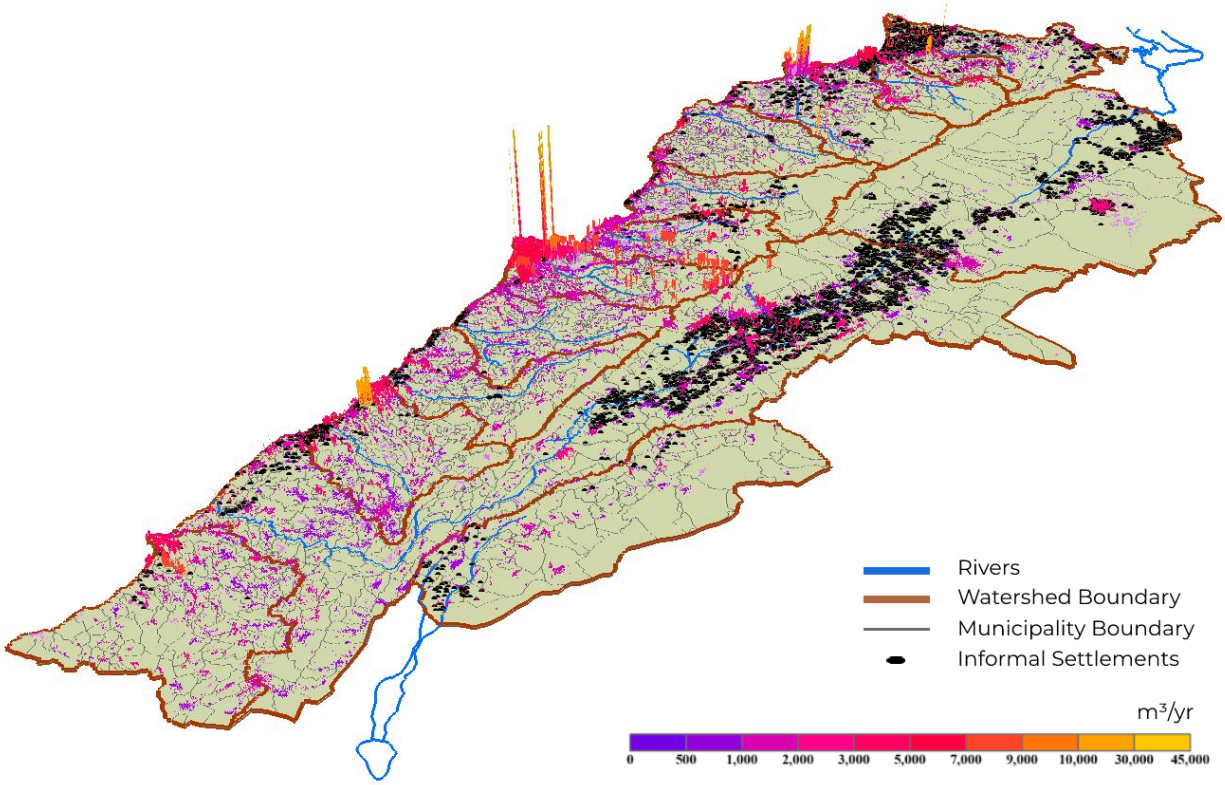

Figure 2. The complex interactions between an increased domestic water demand (m^3/year), informal refugee settlements (black dots), and water systems need to be studied to decrease stress on the natural resource base.

3. Water quality and pollution

Water for refugees in informal settlements is being sourced from private tankers or through the drilling of additional wells by NGOs in an already stressed aquifer[5], or is supplied by the municipality using the same infrastructure that can barely supply water to the host communities. In Lebanon, domestic water is delivered to houses via pipes from pumping stations once every other day (Beirut), once every three days (other areas), and in late summer it can be once every week or even 15 days for three hours/district only [6]. Over the period 2013-2018, a hydrologic-remote sensing coupled analysis showed that water levels in some areas of the Bekaa Valley fell by 15 meters[7]. There is evidence of increasing water pollution in watersheds where refugees are concentrated. The solid waste generated by 300,000 refugees located in informal camps in the Bekaa Valley is not being treated and in many cases it is dumped directly into the Litani River. Recent analysis of irrigation water extracted from the Litani River in the Bekaa Valley showed the existence of Colistin (a last resort antibiotic) resistant E. coli[8] bacteria,

[5] (MoEW-UNDP, 2014)
[6] (H. Jaafar et al., 2016)
[7] (H. H. Jaafar & Ahmad, 2020)
[8] (Hmede, Jaafar, & Kassem, 2019)

which was later found in domestic and well water in refugee camps[9], as well as in the Mediterranean Sea coast of Lebanon near sewage outlets[10].

4. Energy demand and consumption

With a rising refugee population, the energy demand for domestic water pumping has increased by a larger percentage than the percent increase in population. This is because the power needed for pumping is related to the multiple of both the pressure and the flow rate. When the required flow rate increases for the same pipe diameters, the friction loss will also increase and hence the energy demand will increase with the population non-linearly, mostly as a quadratic function. Fuel for electricity production and transportation is also imported. Fuel consumption increased by 30% from 37 thousand barrels per day in 2011 to 49 thousand in 2017. Electricity consumption also increased by 20% from 14 billion KWh in 2011 to 17 billion in 2017[11]. This increase in energy demand and consumption has led to higher air pollution levels and has put more strains on the country's fragile economy.

5. Food security

The sudden increase in population due to refugee crisis has and will continue to put more pressure on food and economic security. Recent reports have shown than three out of four Syrian refugees in Lebanon have an acceptable food consumption[12]. Lebanon relies mainly on food imports in foreign currency, and the trade balance surged to a negative trade deficit of USD 17 billion in 2018[13] (6 times the country exports). Lebanon imports more than 90% of its red meat and fish, and more than 90% of the feed required for dairy, chicken and egg production[14]. Cereals for bread, as a major component of the diet, as well as rice and legumes are also imported. Syrian refugees have been reported to consume all of the above. The demand for foreign currency during the last 10 years has therefore increased dramatically. Demand on local vegetables has likely also increased and would put more pressure on the water resources in the country as more water is needed for irrigation. Overall, annual economic growth in the country dropped from more than +7% in 2010 before the crisis to -6.9% in 2019[15].

6. Susceptibility to climate hazards

There is still no evidence for a decreasing precipitation trend over Lebanon for the last 40 years (Figure 3). While the impact of climate change on refugees and host communities in the short and medium-term is much milder than the impact of the abrupt increase in the refugee population in the country, climate hazards are affecting refugees residing in informal settlements since the beginning of the Syrian conflict, both in Syria[16] and Lebanon[17]. Because the camps were located in flat and mainly agricultural areas in Lebanon, they were subject to floods in the winter (Akkar and Central Bekaa areas). Refugees

[9] (Kassem, 2020)
[10] (Sourenian et al., 2020)
[11] https://www.theglobaleconomy.com/Lebanon/electricity_consumption/
[12] http://ialebanon.unhcr.org/vasyr/files/vasyr_chapters/7%20VASyR%202019%20Food%20Consumption.pdf
[13] https://wits.worldbank.org/CountryProfile/en/LBN
[14] (Mourad, Jaafar, & Daghir, 2019)
[15] https://www.theglobaleconomy.com/Lebanon/Economic_growth/
[16] https://reliefweb.int/report/syrian-arab-republic/north-west-syria-severe-floods-kill-one-child-and-force-least-20000
[17] https://www.concern.net/news/syrian-refugees-hit-by-floods-in-lebanon

residing in camps located in the harsh environment of Aarsal[18] in Northeastern Bekaa suffered from extreme cold temperatures and snow storms in the winters. International agencies may need to resort to a rapid suitability assessment and climate vulnerability studies for locating camps and also for mitigating risks.

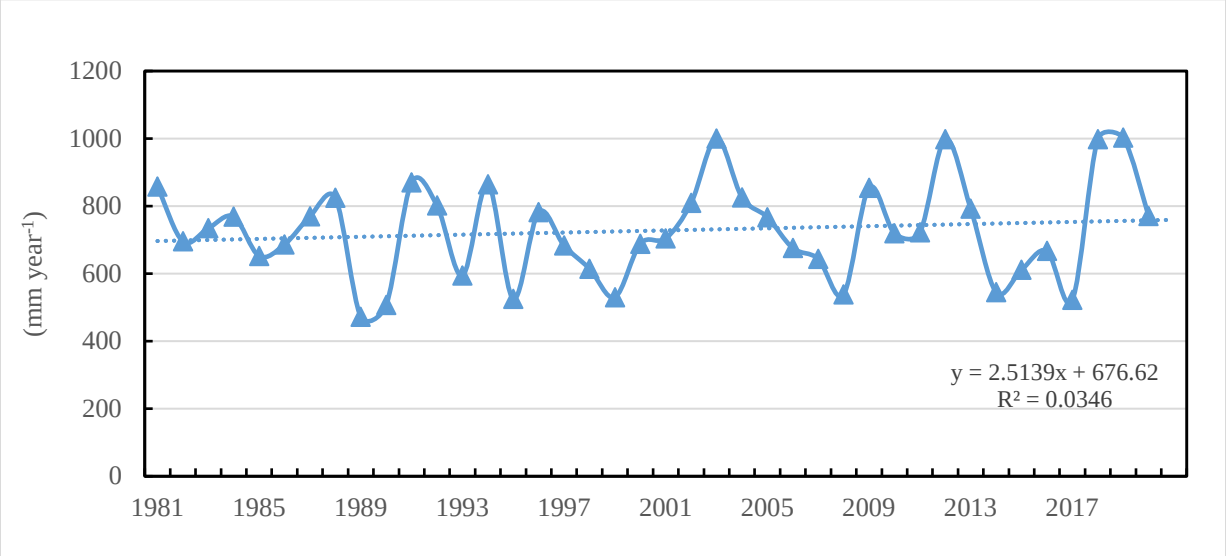

Figure 3. Spatial Mean annual precipitation over Lebanon for 1981-2020. Raw data is from Climate Hazards Group Infrared Precipitation with Station data (CHIRPS)[19]

7. Conclusion

The depletion of water resources and the environmental degradation will affect both the host and the refugee communities as they both share the same natural resource base. Refugees in informal settlements remain vulnerable. While refugees should never be blamed for this situation, the international community and the concerned governments need to work together to find alternative solutions to such crises, as well as to deal with the short- and medium-term environmental implications. The health of and well-being of the refugee communities should be spared from political agendas and should be always protected, while preserving the resources of the host communities. While water cannot be "created", improved management such as network rehabilitation (Figure 4), can help decrease the induced water stress. Conflict resolution should be sought whenever possible to minimize the likelihood of war, for as long as there is war, the refugee crisis will continue to loom over neighboring countries. Geospatial, hydrologic, water accounting and remote sensing tools are necessary to help understand and analyze the impact of hazards and risks on both refugee and host communities.

[18] https://www.hrw.org/news/2019/12/20/winter-looms-lebanons-syrian-refugees
[19] (Funk et al., 2015)

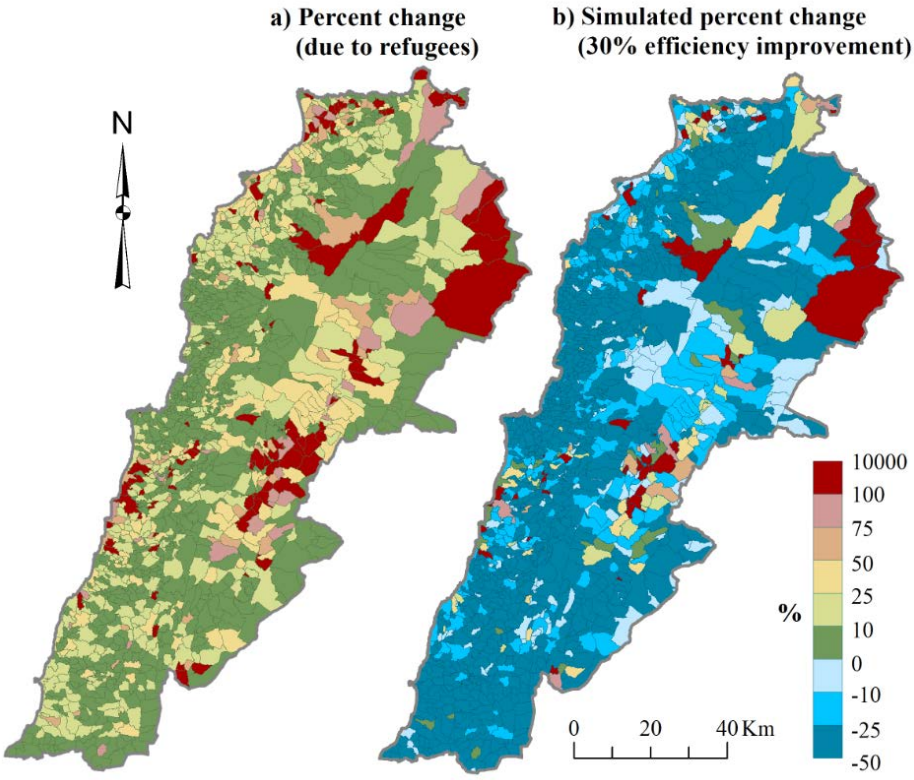

Figure 4. Percent increase in domestic water demand due to the refugee-crisis in Lebanon (a). A 30% increase in water network efficiency can reduce water stress to pre-conflict levels[20].

[20] (H. Jaafar et al., 2020)

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