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MAPPING OUT VULNERABILITY: CLIMATE CHANGE AND THE SYRIAN REFUGEES IN LEBANON

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Abstract

In Lebanon, the ongoing Syrian refugee crisis intersects with severe environmental transformations, creating a complex landscape of vulnerability. This research investigates the intersection of climate change and the Syrian refugee crisis in Lebanon, utilizing a Geographic Information Systems (GIS) approach to map out vulnerability and identify areas of critical concern. By analysing data on refugee hosting districts, food insecurity, climate resilience, water stations, and health facilities, the study aims to understand the complex interplay of these factors in shaping the vulnerability of Syrian refugees to climate-related impacts. Spatial exploration of data allows identification of hotspots of vulnerability, assesses the availability of essential resources, and evaluates the effectiveness of adaptation measures. The findings contribute to a deeper understanding of the challenges faced by Syrian refugees in Lebanon and provide valuable insights for policymakers and humanitarian organizations to develop targeted interventions and enhance resilience.

Keywords: Climate change, Syrian refugees, Lebanon GIS data, environmental transformations

Introduction

As the effects of climate change become increasingly apparent, vulnerable populations around the world face disproportionate risks and challenges. The Mediterranean region, particularly its southern and eastern areas, is expected to face much harsher climate change effects than other parts of the globe. By 2100, temperatures in this region could increase by 3-5 degrees Celsius compared to the global average, and rainfall on the southern coast might decrease by 35 percent. Sea levels are predicted to rise by approximately 35 centimetres. Moreover, droughts are likely to occur more often and be more severe in the Mediterranean.

As an Eastern Mediterranean country, Lebanon is situated in a region highly susceptible to climate change impacts. Its mountainous terrain and coastal location make it vulnerable to extreme weather events like droughts, heatwaves, floods, and landslides. In addition, Lebanon is already facing chronic water scarcity due to its arid climate and high population density. Climate change is exacerbating this issue through reduced rainfall and increased evaporation.

In Lebanon, the ongoing Syrian refugee crisis intersects with severe environmental transformations, creating a complex landscape of vulnerability. Break out of Syrian Civil War in 2011 led to one of the greatest humanitarian crises in recent history. More than 350,000 Syrians lost their lives, while millions were injured and more than half of the Syrian population were displaced from their homes. This situation has had a severe impact on Lebanon, which

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is a neighbouring country and has received the greatest number of refugees in relation to its population in the world (Norvegian Refugee Council, 2023). While refugees constitute 22 percent of the total population in Lebanon, the influx of Syrian refugees has increased Syrian population by 40 percent (UNHCR, 2023). The influx of Syrian refugees has placed additional strain on Lebanon's resources, including water, energy, and infrastructure. This makes the country even more vulnerable to the effects of climate change.

In summary, Lebanon's unique geographic, environmental, and socioeconomic conditions make it a particularly important case study for understanding the impacts of climate change and developing effective adaptation strategies. This study seeks to examine the multifaceted impacts of climate change on Syrian refugees living in Lebanon, emphasizing how environmental stressors such as water scarcity, extreme weather events, and deteriorating agricultural conditions exacerbate their precarious situation. By mapping out these vulnerabilities, this study aims to illuminate the urgent need for targeted interventions and policies that address both humanitarian and environmental concerns. This intersectional analysis not only highlights the extent of Syrian refugees' resilience but also underscores the critical role that climate adaptation strategies play in safeguarding their future and enhancing community resilience within Lebanon.

The rest of the paper is organized as follows. Section 2 focuses on the unfolding of climate change in Lebanon and its negative outcomes. Section 3 elaborates literature on climate change and refugee vulnerability. Section 4 investigates the intersection of climate change and the Syrian refugee crisis in Lebanon, utilizing a geographic information systems (GIS) approach to map out vulnerability and identify areas of critical concern. Section 4 makes the concluding remarks and presents some policy implications for resilience and adaptation.

Climate change in lebanon

Lebanon is located in the Eastern Mediterranean and the Middle East (EMME) which is considered as a critical region where negative consequences of climate change are heavily felt by the regional societies. These negative consequences include quite high temperatures, intensive droughts and serious floods (Waha et al., 2017, p.1623; Lelieveld et al, 2012, p.667; Wehrey et al., 2023). As Rignall (2019, p.629) rightfully points out, the world has reached to a threshold regarding the disastrous global impacts of climate change whose weight are not felt evenly by the states and the people. While historically, states in the EMME region have relatively less contributed to carbon emissions when compared with the industrialized states, they have been the people of region to have suffered more from climate-related disasters. Societies in the region face numerous health risks such as respiratory and cardiovascular diseases which are mostly aggravated by increasing heat, poor air quality and decreasing of fresh water (Waha et al., 2017, p.1631).

Climate change in combination with rapid population growth and declining precipitation has particularly led to water stress in the EMME which has already been well-known as the most water scarce region (Terink, Immerzeel and Droogers, 2013, p.3055). The water resources of the region are expected to decrease further, reaching alarming levels which in return would cause significant political, economic and social changes (Chenoweth et al., 2011, p.1). Mahmoud (2024) underlines the fact that "the gap between water supply and water demand" in the region has been increased due to drought conditions triggered by climate change and that the stability of the region is highly dependent on whether the issue of water scarcity will be properly addressed, and water management will be improved or not. There has been increasing scholarly attention on the issue of water scarcity in the region and projections reveal important water shortages for most parts of the region in the future (Bou-Zeid and El-Fadel, 2002, pp.345-346). In fact, climate change is not the only cause of water shortage in the region. Rather it acts as a risk-multiplier through exacerbating the impact of "large-scale water management problems" in the region including over-pumping of the aquifers, increased irrigation in agriculture and water pollution (Terink, Immerzeel and Droogers, 2013, p.3055).

Within the EMME region, it is fair to suggest that relatively Lebanon has a more favorable climate when compared with most of the other states. However, in the last decades Lebanon has also had its share from global climate change problems which has been reflected through increase in temperature and decrease in rainfall averages (Taher, 2019, p.21). Halwani (2009) points out that Lebanon is clearly experiencing climate change phenomenon when its "meteorological and hydrological records over the past three decades" are taken into consideration. The negative effects of these records have intensified when combined with a significant increase in population size in the country. Climate change is estimated to have greater damaging consequences on Lebanese environment, economy, development, agricultural production and public health through time (Taher, 2019, p.20).

There are mainly four leading problems associated with climate change in Lebanon. The first one and the most urgent one to be addressed is declining water supplies. In fact, Lebanon is known with its abundant water resources supported by many river systems. In this regard, the country is stated to have a "relatively fortunate hydrological position" (Halwani, 2009). However, according to Bou-Zeid and El-Fadel (2002, p.348) while Lebanon possesses higher water resources per capita in comparison with other regional states, by the year 2025 it will not be able to meet its local demand. The volume of available water in Lebanon has been in a steady decline in the last four decades due to a combination of factors such as decreasing rainfall and snow cover, human interference, mismanagement and absence of public awareness on water use (Halwani, 2009). With annual increase in temperatures, Lebanon's mountains receive less snow each year leading to decreasing amount of ground water each year which in return threatens water supplies for consumption and agriculture (Wehrey et al., 2023). The 1975-1990 Civil War also played a devastating role on the water infrastructure in the county whose side-effects have continued to be seen on the water resources (Bou-Zeid and El-Fadel, 2002, p.349).

Another problem associated with climate change in Lebanon is air pollution. High dependence on fossil fuels has soared air pollution in the country. Wehrey et al. (2023) state that Lebanon has one of the highest health costs in the region, "$900 million annually", due to air pollution. Diesel generators which are widely used in the country in response to ill-management of electricity by the Lebanese authorities and heavy reliance of

Beirut's transportation system on carbon-emitting fuels have also contributed to climate change in the country (Wehrey et al., 2023). It is reported that Lebanon's electricity system is broken since 2019 and "8,000 diesel generators" have powered Lebanese leading devastating effects on air quality and public health (Cheeseman, 2024). Mishandling of wastes which leads to regular burning of trash and releasing of important quantities of toxic chemicals is the third leading problem associated with climate change in Lebanon. Lastly, wildfires and deforestation are closely associated with climate change in Lebanon. Wildfires have expanded in recent years in line with the increasing heat in the country. Wildfires combined with urban growth, diseases, insects and quarries have seriously threated Lebanese forests (Jezzini et al., 2023, p.2).

These above-mentioned problems associated with climate change are further exacerbated with growing population in the country. Lebanon has already been hosting Palestinian refugees when the country also opened its doors to Syrian refugees in the aftermath of the starting of the Syrian civil war in March 2011. The rapid increase in population have caused greater demand for already declining resources such as water. For instance, the Bekaa Valley is known to accommodate significant number of Palestinian and Syrian refugees in addition to local Lebanese which has stressed Bekaa Valley's water resources (Slaymane and Soliman, 2022, p.1). This stress on the Bekaa Valley's water resources is particularly reflected on the deteriorating water quality in the Upper Litani River Basin (Slaymane and Soliman, 2022, p.2).

In the meantime, mismanagement of the country for decades has had detrimental effects on environment and climate. Lebanon has been experiencing political and economic crises particularly since 2019 which has led ruling elites to ignore climate change concerns. Corruption and mismanagement of resources have heightened the impact of climate change in Lebanon and have made Lebanese people more vulnerable to climate crisis (Wehrey et al., 2023). The authorities have turned a blind eye to the waste contaminating drinking water, diesel generators spreading toxic chemicals, excessive use of groundwater and contamination of agricultural lands through irrigation with sewage water (Germanos and Azzi, 2024). According to Wehrey et al. (2023) poor governance and mismanagement of resources have impeded any meaningful climate action to take place in Lebanon and this situation has only worsened the negative consequences of climate change.

Overall, it is fair to suggest that climate change has constituted a further challenge to Lebanon's stability due to inconsistencies regarding the provision of basic services by the authorities such as access to clean water, breathable air and reliable sources of power (Al-Sarihi et. al., 2021, p.3). The consequences of climate change have seriously curtailed the wellbeing of the Lebanese people and the ruling elites need to develop policies and regulations to cope with these challenges to break the vicious circle with respect to instability in the country.

Climate change and vulnerable populations

While climate change has negative impacts on the humanity as a whole in terms of enjoyment of basic human rights such as access to drinkable water, shelter and sanitation, people in vulnerable contexts are subject to aggravated harms of it. According to the United Nations Human Rights Office of the High Commissioner (OHCHR, 2022), people may experience greater vulnerability in the face of climate change due to various factors including "geography, poverty, gender, age, indigenous or minority status, national or social origin, birth or other status and disability". For instance, inhabitants of less developed states, small island developing states, and those regions exposed to widespread droughts, floods and desertification are more affected from the severe consequences of climate change. The vulnerability of people living in climate change-fragile regions are further heightened with weak adaptive capacity and ill-management disaster risks of their states since they cannot practice their human rights effectively or in full sense.

Refugee communities are a significant component of vulnerable populations with respect to climate change. UNHCR (2024) state that refugee communities are largely located in "climate change hotspots, prone to the effects of climate change and natural disasters, which compromises their security and places them at risk of secondary displacement". It is pointed out that the regions and the countries which are most prone to climate risks are also the ones to collectively host "28 percent of all refugees" (UNHCR, 2024). OHCHR, (2022) report on the negative impacts of climate change on vulnerable populations suggests that climate change is not only an environmental crisis but also a social justice crisis that needs to addressed taking into consideration the link between climate justice and social equality. In fact, vulnerable communities facing harmful effects of climate change do not live only in less developed or developing parts of the world but there are also such vulnerable communities within countries located in the Global North.

The literature on the impacts of climate change mostly focuses on the vulnerability of specific regions or countries to climate change risks such as droughts in the Sahel region, precipitation in Norther Europe or heatwaves in the Middle East, yet there is relatively less research on the impact of climate risks on specific societies and communities (Broberg, 2017, p.103). Particular populations are highly vulnerable to climate impact due to a combination of geographical risks and neglect by national authorities (Wehrey et al., 2023). Challenges to climate change adaptation are greater in less developed or developing parts of the world due to already existing developmental problems. In such contexts, climate change acts as a "threat multiplier" intensifying present socio-economic complications, destabilizing livelihoods, and increasing the chance of tensions (Sanni et al., 2022, p.1). This is especially the case for relatively more vulnerable populations such as the refugees since negative consequences of climate change hurt them the most.

For instance, Congolese and Burundian refugees in Rwanda are frequently exposed to serious risks of climate-related disasters including floods and landslides (Dampha et al., 2022, p.42). Available lands for constructing refugee camps are considerably limited in the country leading refugee camps to be located in remote areas where climate risks are higher. Dampha et al. indicate that refugee camps in Rwanda are often hit by extreme weather events, and it is difficult to talk about any adaptation (Dampha et al., 2022, p.42). Another example is from Sudan which has been hosting more than 1 million refugees from different countries. Following the Tigray War (2020-2022) in Ethiopia, thousands of Ethiopian refugees sought shelter in Sudan. Most of these refugees settled in the Gedaref state, East Sudan where they experienced tough weather conditions such as "heavy rains, strong storms,

severe floods, and heat waves which resulted in over 50% loss of their shelters and belongings" (Ahmed et al., 2021, p.1). When poor welfare services were accompanied by the severe effects of climate change, there has been a significant increase in the vulnerability of the Ethiopian refugees. In their research Ahmed et al. (2021) clearly demonstrate that climate change risks have aggravated the challenges to the health, security and welfare of the Ethiopian refugees in Sudan.

Like the refugees in Rwanda and Sudan, Rohingya refugees in Bangladesh have also been exposed to climate disasters. Bangladesh with its dense population is regarded as the most vulnerable country to climate impacts in South Asia. The country has been hosting Rohingya refugees who fled neighboring Myanmar due to ethnic cleansing to seek settlement and safety in Bangladesh. The Rohingya refugee camps are predominantly located in flood-prone Cox's Bazar in Eastern Bangladesh (Malji, Obana, and Hopkins, 2022, p.946). Rohingya refugee camps in Cox Bazar were hit by climate tragedies including cyclones, flooding and landslides causing further humanitarian crises (Malji, Obana, and Hopkins, 2022, p.939). The climate risks faced by Rohingya refugees have been accelerated by the temporary nature of the Rohingya's housing which is not resistant to such climate disasters (Malji, Obana, and Hopkins, 2022, p.946).

Among the refugee-hosting states, Lebanon stands out for hosting the greatest number of refugees per capita in the world. Lebanon has been hosting approximately 1.5 million Syrian refugees who sought refugee in neighbouring countries including Türkiye, Jordan and Lebanon following the outbreak of the Syrian civil war by March 2011. Lebanon had already been hosting a significant number of Palestinian refugees since 1948 prior to the flow of Syrian refugees. Since the Palestinian refugee camps largely became permanent through time, in order not to experience the Palestinian refugee case again, the Lebanese government adopted non-encampment policy towards the Syrian refugees. According to Tiwari, Al Azzawi and Amir (2023, p.3), non-encampment policy aimed at ensuring that "the nature of the settlements could not be that of a permanent settlement". For this reason, the Syrian refugees have been scattered informally across Lebanon. Kikano and Lizarralde (2019, p.29) point out that non-encampment policy implemented by Lebanon led Syrian refugees to spread to roughly 2000 locations except for a few authorized camps.

Despite the spread of Syrian refugees throughout Lebanon, the highest share of the Syrian refugee population has been informally settled in Bekka Valley in eastern Lebanon mostly in precarious settlements such as shelters and tents (Tiwari, Al Azzawi and Amir, 2023, p.2). It is stated that around 42,000 illegal tents are spread to approximately 1500 locations across the country most of which take place in the North and mainly concentrated in the North and in the Bekaa Valley (Trovato, 2019, p.43). The Bekaa Valley is known to be predominantly agricultural accompanied by ill infrastructure and weak economy, which mainly accommodates shanty towns and temporary settlements constructed of wood and plastic covers (Tiwari, Al Azzawi and Amir, 2023, p.3). Settlements in the region mostly lack access to welfare services and face various risks. Roughly, one million Syrian refugees are registered with the United Nations High Commission on Refugees (UNHCR) who, although insufficient, can benefit from formal assistance whereas there are unidentified number of unregistered Syrian refugees who cannot benefit from any assistance triggering the extent of their vulnerability (Nabulsi et al., 2020, p.1).

The emergency shelters were built as temporary settlements, but due to prolongation of the civil conflict in Syria, they turned into permanent informal settlements with inadequate facilities (Tiwari, Al Azzawi and Amir, 2023, p.1). Syrian refugees living in such shelters are exposed to various vulnerabilities. These informal shelters do not meet basic standards of living. Kassem and Jaafar (2020, p.423) indicate that many Syrian refugees including "children, elderly, and immunocompromised individuals, have limited access to basic needs such as clean water and sanitation, robust medical support, and safe and nutritious foods". This low quality of living has had negative health consequences on the Syrian refugees and the vulnerability of the refugees further increased with climatic extremes in the country.

Lebanon already had political, economic, social and environmental problems prior to welcoming Syrian refugees (Kuscevic and Radmard 2020, p.417). A serious and sudden increase in population has placed an enormous pressure on the country's existing problematic infrastructure and services. For instance, settling of a large number of Syrian refugees in Bekaa Valley has constituted an important strain on the water and waste infrastructure in the region. The refugee settlements receive their water "by trucks, through the existing water network, or from new boreholes drilled close by" and "only a third of all Syrian refugees have access to tap water for more than two hours per day" (Kassem and Jaafar, 2020, p.424). Another inadequacy occurred in the field of energy. Lebanon's already limited energy supplies were negatively affected from additional demand with the coming of Syrian refugees (s and Collins, 2020, p.2).

Overall, climate change has clearly been aggravating the vulnerability of Syrian refugees who have already been exposed to various difficulties. Informal settlements are highly unresistant to devastating effects of climate-related disasters such as increasing temperatures, heavy winds, droughts and floods. In the meantime, it would be fair to suggest that unplanned growth of informal refugee settlements and the excessive use of energy, soil, water and waste infrastructures have heightened environmental degradation in the country (Trovato, 2019, p.44).

GIS Analysis of Climate change and vulnerability in Syrian Refugee Hosting Districts in Lebanon

Lebanon's unique geographical location, environmental conditions, and socio-political context make it particularly vulnerable to the impacts of climate change. This vulnerability is further exacerbated by the ongoing Syrian refugee crisis. Bu understanding the complex interplay between climate change and refugee vulnerability in Lebanon, policy makers, humanitarian organisations, and researchers can develop effective strategies to mitigate impacts and build resilience. This section analyses key aspects of climate change and refugee vulnerability in Lebanese districts, utilising GIS data. GIS Overlay Analysis is conducted since, it is a powerful tool for analysing and visualizing the complex relationship between climate change and refugee vulnerability in Lebanon. By integrating various datasets, such as those on refugee

hosting districts, food insecurity, climate resilience, water stations, and health facilities, overlay analysis is expected to identify areas of critical concern and assess the potential impacts of climate change on vulnerable populations.

In order to conduct the overlay analysis, open-source GIS software QGIS is used. The hypothesis tested in this research is;

H: Refugee settlements in Lebanon are more vulnerable to the effects of climate change compared to local Lebanese communities due to inadequate infrastructure and resources.

The positioning of refugee settlements in relation to climate-risk zones and their proximity to infrastructure will highlight areas of vulnerability and the situation of refugees.

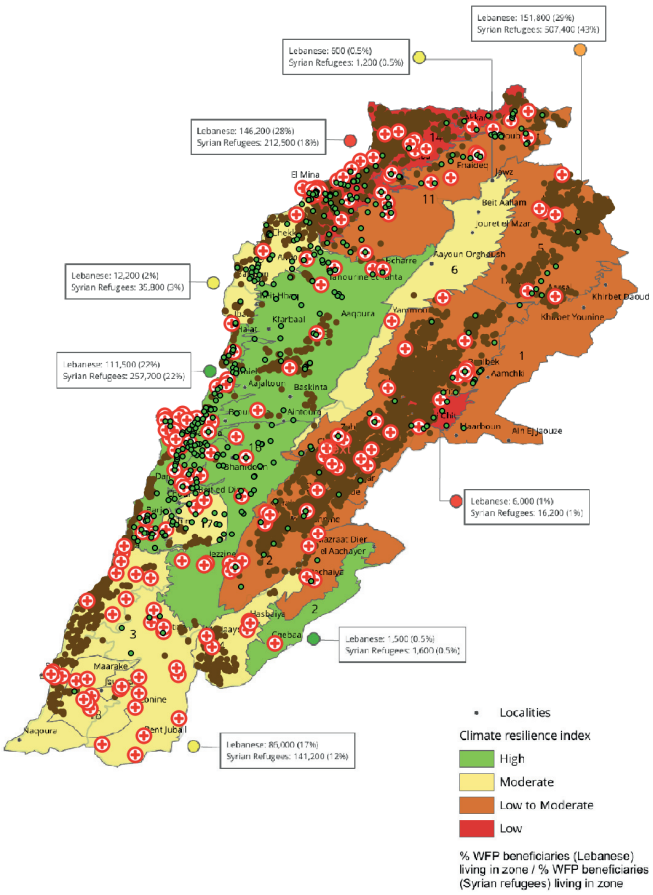
The geospatial data of informal refugee settlements, water stations, health facilities are collected from WFP Lebanon GIS Portal. Lebanon Climate Resilience Index, constructed by WFP Lebanon Country Office, is used a base layer. Refugee settlements and infrastructure data (water stations and health facilities) are overlaid on the base layer.

Figure 1 visualises findings of the overlay analysis. Base layer consists of colour-coded Lebanese regions, based on their climate resilience. Climate resilience is categorised into four levels: high resilience (green). moderate resilience (yellow), low to moderate resilience (orange), and low resilience (red). Percentage and number of of Syrian and Lebanese WFP beneficiaries receiving assistance in each region are also indicated. The significant number of WFP beneficiaries among both Lebanese and Syrian populations highlights the critical need for food assistance. Northern regions (i.e. Akkar, Tripoli), and eastern regions (i.e. Baalbek) show high dependence on food assistance. These regions are highly populated regions with poorer climate resilience, which suggests that both local and refugee populations in these regions are experiencing substantial food insecurity due to environmental stress, such as draught or poor agricultural productivity.

The second layer of the map displays the distribution of Syrian informal settings, represented by brown dots. Lebanon's non-encampment policy led to spread of informal settings over the region. Higher concentration of refugees' informal settings in regions with lower climate resilience potentially increases their vulnerability to climate related challenges such as draughts, floods, or poor agricultural conditions.

Finally, the third layer of the map shows the distribution of resources (i.e. water stations and healthcare facilities) across the regions of Lebanon. Red circles with crosses mark healthcare facilities while green dots represent water stations. Healthcare facilities and water stations are scattered across Lebanon, encompassing both urban and rural areas, as well as regions with low and high climate resilience. Yet, refugee settlements often appear in areas with limited access to hospitals and water stations, highlighting a disparity in infrastructure compared to more urbanised or Lebanese – majority areas. In addition, a higher proportion of WFP beneficiaries among Syrian refugees compared to Lebanese in regions of North Lebanon and Bekaa reflects greater economic vulnerability. Particularly, Akkar, Baalbek–Hermel, and the Bekaa Valley are marked by high population density, fewer healthcare facilities, and limited water stations, suggesting a strain on resources and potential challenges in accessing basic services. In conclusion, visualised data shown in Figure 1 supports the hypothesis that refugee settlements in Lebanon are more vulnerable to the effects of climate change compared to local Lebanese communities due to inadequate infrastructure and resources.

Figure 1: Spatial Vulnerability of Syrian Refugee Settlements to Climate Change in Lebanon



Source for base map: 'WFP GIS Portal (2022). 'Lebanon The Most Vulnerable Refugee Hosting Districts Map'(https://gis.lbn.wfp.org/portal/apps/sites/#/lebanon-gis-portal accessed 16.08.24).
Source for Syrian List of Informal Settlements, Water Stations, Health Facilities: WFP Lebanon GIS Portal (2022). LBN Data on Points of Interest. (https://gis.lbn.wfp.org/portal/apps/sites/#/lebanon-gis-portal accessed 16.08.24).

Concluding remarks

In Lebanon, dire living conditions of the Syrian refugees are intertwined with increasing negative effects of climate change, resulting in a complicated scenario of vulnerability for the refugees. By employing a GIS overlay analysis, this research has mapped out the various dimensions of vulnerability that arise from both climate-related impacts and socio-economic challenges faced in the country. The findings indicate that the Syrian refugees in Lebanon are situated in precarious conditions, often living in informal settings with inadequate infrastructure and limited access to critical resources, such as clean drinking water and healthcare services. The geographic overlay of refugee settlements with climate resilience data underscores how these communities

are disproportionately affected by environmental stressors, including rising temperatures and diminishing water supplies. Such vulnerabilities not only threaten the immediate health and wellbeing of the refugee population, but also strain the already challenged resources of host communities.

Furthermore, this research underlines the urgent need for effective policy interventions that integrate humanitarian efforts with climate adaptation strategies. Policy makers and humanitarian organisations must prioritise targeted initiatives that address both the pressing climate change challenges and the sociopolitical dimensions impacting Syrian refugees in Lebanon. Such a comprehensive approach can facilitate improved resilience and better conditions, ultimately assuring to safeguard the wellbeing of one of the most vulnerable populations in the region.

In this regard, Lebanese policy makers should implement policies to reduce GHG emissions through adopting strict legislation and tax incentives and encouraging investments on renewable energy. In addition, steps should be taken to increase public awareness among the hosting community and the refugees regarding climate change. Obviously, it is not an easy task to adopt such measures in a proper way when the current Lebanese political and economic contexts are taken into account. The country has been experiencing serious political and economic stability. Moreover, at the first anniversary of the Hamas' October 7 attack on Israel and the following ongoing war in the Gaza Strip, Israel's attacks on Lebanon against Hizbullah targets have further complicated the political, economic, security and humanitarian situation in the country. In this context, developing effective adaptation strategies to protect both the hosting community and the refugees from the harmful impacts of climate, seems unlikely in the short-term. It is fair to suggest that effective management of the climate crisis requires institutional reforms, capacity-building and capital investment. Here, it is also in the responsibility of the international community to support Lebanese government in reducing the vulnerability of the refugees in the country and offering displaced people a dignified living.

Data availability statement

The original contributions presented in the study are included in the article/supplementary material, further inquiries can be directed to the corresponding author.

Author contributions

The authors confirm being the sole contributor of this work and have approved it for publication.

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Conflict of interest

The authors declare that they have no known competing financial interests or personal relationships that could have appeared to influence the work reported in this paper.

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