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REVIEW OF RECENT EVENTS IN LEBANON (2011–2020) AND THEIR EFFECT ON LAND DEGRADATION

RESEARCH PROJECT ON LAND GOVERNANCE IN THE ARAB REGION

Mario J. Al-Sayah, Rita Der Sarkissian, Chadi Abdallah

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United Nations Human Settlements Programme (UN-Habitat)
PO Box 30030 GPO Nairobi 00100, Kenya
Tel: +254 20 762 3120
Fax: +254 20 762 3477
www.unhabitat.org

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Task Managers: Doaa El Sherif and Ombretta Tempra

Authors: Mario J. Al-Sayah, Rita Der Sarkissian, Chadi Abdallah

Reviewer: Rafic Khouri

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For more information, please consult the referenced documents, visit **www.gltn.net** or write to **unhabitat-gltn@un.org**

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ABBREVIATIONS

ACLED	Armed Conflict Location and Event Data Project
CAS	Lebanese Central Administration of Statistics
CDR	Council for Development and Reconstruction
CNRS	National Council for Scientific Research
CNRS-RSC	National Council for Scientific Research – Remote Sensing Center
CORINE	Lebanese adapted Coordination of Information on the Environment
DGU	Directorate General for Urban Planning
ELD	Economics of Land Degradation
ESCWA	United Nations Economic and Social Commission for Western Asia
EU	European Union
FAO	Food and Agriculture Organization of the United Nations
GDP	Gross Domestic Product
GEF	Global Environment Facility
IAMP	Inter-Agency Mapping Project
ILO	International Labour Organization
IMF	International Monetary Fund
IOM	International Organization for Migration
GLTN	Global Land Tool Network
LBP	Lebanese Pound
LDN	Land Degradation Neutrality
LU/LC	Land Use/Cover
MENA	Middle East and North Africa
MoA	Ministry of Agriculture of Lebanon
MoE	Ministry of Environment of Lebanon
OCHA	United Nations Office for the Coordination of Humanitarian Affairs
PRECIS	Providing REgional Climates for Impacts Studies
SDGs	Sustainable Development Goals
PRIO	Peace Research Institute Oslo
SIPRI	Stockholm International Peace Research Institute
USIP	United States Institute of Peace
UNCCD	United Nations Convention to Combat Desertification
UNDP	United Nations Development Programme
UN-Habitat	United Nations Human Settlements Programme
UNHCR	United Nations High Commissioner for Refugees
USD	United States Dollar
WFP	World Food Programme
WHO	World Health Organization

EXECUTIVE SUMMARY

Less than a decade away from the 2030 sustainable development horizon, Lebanon is in a state of crisis. As part of the Arab countries and the Mediterranean region, the history of Lebanon has long been associated with conflicts, wars and instability. During the last decade alone, a series of intrinsic and extrinsic events rattled the country. These factors handicapped the country's capacity to socially, technologically and economically adapt to the advancing changes, generating a very vulnerable context. Internal factors arise from Lebanon's fragile sociopolitical system, precarious institutional framework and stagnant economy; while external factors are largely related to the country's sensitive geopolitical position. With an area of 10,452 km2, Lebanon is the third smallest country of the Arab region, but its third most densely populated nation.

Since the 1950s, chaotic urban expansion has encroached on the country's prime lands. The 1975–1990 war period and post-war phases made matters worse with uncontrolled destruction, followed by unregulated expansion over agricultural and natural areas. While state-classified lands total only 10 per cent, uncontrolled exploitation of lands in the absence of management plans is prevalent. With a heavily dollarized economy prone to destabilization, and the world's third-highest public debt, the economic performance of Lebanon has been far from steady or sustainable. Constant conflicts, internal political shocks and external contributions added a layer of complexity to the already precarious national security, demographic, environmental and economic situation.

The year 2011 was the starting point for a series of events that marked its recent history. As a result of the 2011 Syrian crisis, mass waves of displaced populations entered Lebanon, settling largely in the nation's most vulnerable regions. The influx has remained constant, and today Lebanon hosts the largest number of refugees per capita in the world. In 2012 and 2013, several local political shocks followed in the wake of the Syrian crisis' spillover. In 2014, while the refugee influx continued, terrorism started to spread across the country targeting the Lebanese armed forces and civilian neighbourhoods. In parallel, the waste disposal system collapsed leaving piles of garbage on the streets (2015–2016). Accordingly, several protests began and popular demands for "regime change" rose in parallel. The events of 2015 and 2016 were linked to the Arab Spring, as intense political episodes were shaking the Arab world.

The year 2017 marked the war on terrorism as the Lebanese army launched the "Fajr Al-Jaroud" operation in the Anti-Lebanon range. A period of relative stability extended through 2018, while 2019 witnessed a series of events starting with terrorist attacks, tension on the southern borders, a large wildfire and the eruption of the October revolution. As the national economy slid into its most extreme downfall, which evolved into a crisis, the COVID-19 pandemic, the Beirut Port explosion and ongoing political unrest only made matters worse in 2020. The events of 2011–2020 combined to increase demands and pressures on land resources and associated services. Collectively, these changes led to considerable land use/cover changes, widened socioeconomic gaps, and escalated already existing – or created new – tensions.

The above-mentioned events are still reverberating in the country, and lands are at the centre of these changes. Overpopulation, overexploitation, urban expansion, rapid unplanned land use/cover changes and natural hazards (floods, wildfires, landslides, droughts, etc.) episodes have directly affected lands. The deteriorating socioeconomic conditions have indirectly caused tangible and intangible effects on the country's land capital. In a small country with finite land resources, a limited number of studies on land degradation have been conducted, and a review linking the above-mentioned events with land degradation and their dimensions is yet to be performed. Therefore, this study presents the first review of recent events in Lebanon and their effect on national land degradation.

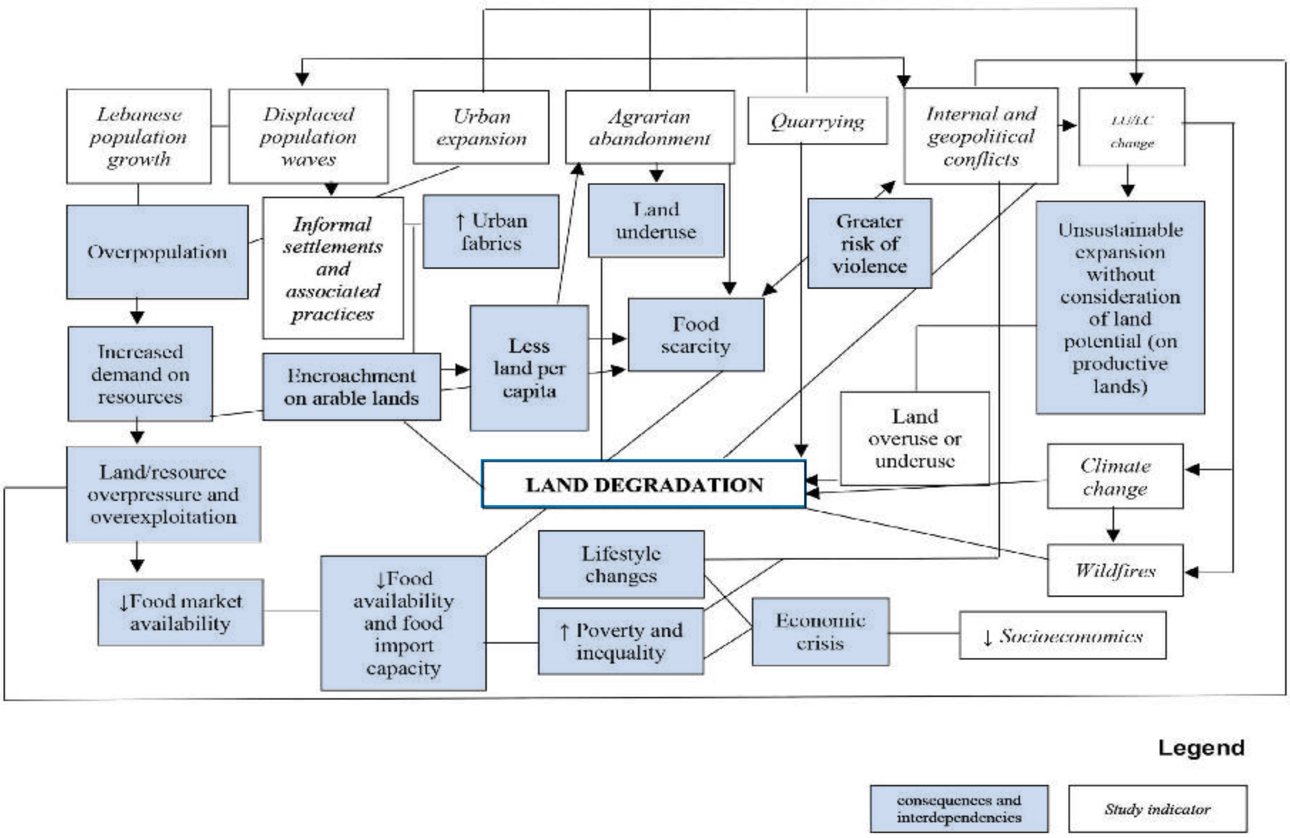
While classical studies usually assess biophysical and socioeconomic drivers of land degradation independently, this study proposed a set of indicators that combine both angles. The logic behind this approach is to provide accurate representations of land degradation, since inaccurate depictions are the first barrier. Furthermore, questionable decisions regarding the state of lands can make subsequent intervention measures ineffective. Hence, this study introduces a combined set of indicators to provide a holistic assessment framework: (1) the expansion of urban cover and informal settlements and their position, with respect to land capability classes; (2) population changes (residents and non-residents); (3) agrarian abandonment with respect to land capability classes; (4) quarry cover expansion with respect to land capability classes; (5) conflicts and exceptional events; (6) land use/cover and climate change; (7) wildfires and their associated damages; and (8) socioeconomic aspects including the economic crisis of Lebanon, the Beirut Port explosion and the COVID-19 pandemic.

Land capability classification was integrated within several indicators to determine the suitability of the changes with respect to the land's productive capacity. Since land degradation is perceived as a negative or unwanted change to the state of lands,

land capability classification was used to infer the type of mismanagement leading to the loss of the land's capability to provide, retain and sustain eco services. The proposed indicators are hybrid and encompass both the biophysical and socioeconomic context. In addition to the independent importance of each one, the indicators are linked to each other by positive interdependences. According to ESCWA, even though land degradation is one of the most threatening challenges facing Lebanon and the Arab region, data scarcity for land degradation assessment is a significant barrier – hence, the choice to employ representative, justifiable and replicable indicators that can be built using local or open-access global datasets. In this way, the methods presented in this study may extend further than the Lebanese national scale and can be applied in other Arab contexts as an effort to safeguard precious lands.

In Lebanon, the National Council for Scientific Research (CNRS) is the scientific arm of the government. Land degradation studies are one of the several mandates of its Center for Remote Sensing, which was established in 1995 as a leading institution for the integration of updated knowledge in remote sensing and GIS technologies. Designed as a support for decision-making, the Center has proven its role as a common platform between several ministries by tackling various disciplines. Some of its most relevant study areas are natural risk management, forest management, land management and planning, land degradation, hydrology, climate change, monitoring of urban expansion, archaeology, integrated management of coastal areas and watersheds, and conservation of natural resources (water, soil, biodiversity).

To accomplish its tasks, the Center regularly builds databases by using and securing updated information, and by cooperating with several international partners through various projects. The Center is also in charge of producing maps (LU/LC, urban, natural hazard risks, soil, geology, etc.), operating master's, engineering and PhD programmes, and training the staff of various public institutions. As part of its scientific missions, CNRS and its associated national centres (the remote sensing, geophysics, marine sciences centres and atomic energy commission) publish scientific literature in indexed peer reviewed journals. Further, the CNRS and its associated centres disseminate additional knowledge through project-related research outcomes, calls and collaborations. The numerous findings contributed by this study are presented in detail in the corresponding sections. The analysis of each index and its relationship with the other indicators yielded the following entwined complex model that reflects the complexity of land degradation in Lebanon.



Land degradation is one of the most complex developmental, environmental, socioeconomic, and scientific challenges of the 21st century. According to Xie, Zhang, and Lv (2020), 75 per cent of the Earth's surface has already been degraded, with 169 out of 195 countries severely affected by land degradation (UNCCD, 2017a). Ioras, Bandara, and Kemp (2014) estimated that only eleven per cent of the Earth's land will remain usable to feed the population in 2020. According to the UNCCD, 24 billion tonnes of fertile soil are lost each year, and some have become degraded beyond restoration (UNCCD, 2015a). With an increase of five to ten million hectares per year (Stavi and Lal, 2015), land degradation is one of the most serious threats to global food security (Zdruli, 2014; Zdruli et al., 2019). In monetary terms, land degradation causes a loss of USD 490 billion each year (UNCCD, 2014), a USD 6.3 to 10.6 trillion loss of ecosystem services (ELD Initiative, 2015), and a yearly burden of USD 230 billion in global gross domestic product (Nkonya et al., 2015).

While land degradation has long accompanied human development, anthropogenic activities altered lands to the point where humans became the sixth factor of soil genesis (Dudal, 2004). Accordingly, we have often adapted lands to our needs (FAO and ITPS, 2015) in the quest for rapid economic gains. The unsustainable outcome is that the lands needed for sustaining human livelihood and producing food are much scarcer. Therefore, combatting land degradation and restoring degraded lands are a must for overcoming the pressing land shortage problems (Çelik and Akça, 2019).

In modern days, land and soil loss are primary threats facing Asia, Africa, North Africa, and the Americas (FAO, 2019), and the geographical extent of the Arab world makes it vulnerable to land degradation. Expectedly, this is due the fact that 90 percent of the region has arid, semi-arid, and dry sub-humid climates (Abahussain et al., 2002). International interest in land degradation was raised following the devastating Sahel drought of the 1970s, which triggered the first scientific efforts to map land degradation (Caspari et al., 2015). Therefore, it is logical to assume that parts of the Arab region were the starting point for land degradation studies. In addition to its climate challenges, the Arab world suffers from water shortages (Al-Rimmawi, 2012), accelerated population growth (Abahussain et al., 2002), increasing droughts, desertification, and most importantly an already fragile pedological setting (Darwish, Atallah, and Fadel, 2018). According to the World Bank (2019a), more than half of the Middle East and North Africa (MENA) region's total lands and a quarter of its arable lands are degraded. Unless concrete changes in land governance occur in the Arab region (Mohtar, Assi, and Daher, 2017), the above-mentioned intrinsic properties, in addition to extrinsic factors such as unstable socioeconomic conditions and reoccurring conflicts will impede the region's capacity to ensure food security by the 2030 horizon (Darwish, Atallah, and Fadel, 2018). Moreover, these changes will increase the region's reliance on food imports, thereby weakening its food production systems and ultimately amplifying its vulnerability.

Despite being an exception in terms of lands and climate among Middle Eastern countries (Al-Sayah et al., 2019), 40 per cent of Lebanon is under risk of desertification (Darwish et al., 2012), while the remaining 60 per cent are under serious risks of land degradation (Darwish, Faour, and Khawlie, 2004). Moreover, soil erosion rates in the country have significantly surpassed the Mediterranean climate pedogenesis rate (Bou Kheir et al., 2006). According to the World Bank (2019a), Lebanon is the country where most arable lands were lost within the MENA region. While many reasons lie behind the deteriorating state of lands in Lebanon, the few studies on land degradation are yet to piece together a comprehensive picture. Further research on land degradation is needed, and the study seeks to address this scientific gap.

1.1 Land degradation in Lebanon: a complex discipline in a complicated context

The complexity of land degradation appears during the earliest stages of its investigation when attempting to separate between degraded and non-degraded lands (Olsson et al., 2019). This challenge is due to the various and often subjective perceptions/definitions of land degradation, based on the observers' different backgrounds, relationship with land (dependence) and socioeconomic interests (Van der Esch et al., 2017). Accordingly, a farmer's perception of degraded lands as a field with poor productive capacity and low economic profit (Stocking and Murnaghan, 2000) might not fit an ecologist's or an engineer's description of land degradation. Through time, the different perceptions have created different definitions of land degradation and led to non-uniform attributions of the process' causal factors (Al-Sayah et al., 2019). Consequently, the conceptualization, design and acceptance of land restoration, counter-degradation and land reclamation measures also became contested (Kohler et al., 2018). An additional layer of complexity is revealed when the socioeconomic, political and institutional capacities, in addition to the public awareness and willingness for land restoration, are taken into consideration. This state is due to the asymmetrical distribution of land degradation, which mostly covers the Earth's poorest places (UNCCD, 2019). The central position of lands and soils with respect to the lithosphere, hydrosphere and biosphere (Li et al., 2012) makes land and its associated processes – here land degradation – stratified disciplines within different scientific fields. Accordingly, land is a platform of interest in physical, environmental, socioeconomic, political, cultural, historical, literary and judicial disciplines. The cross-cutting and interdisciplinary nature of land make land degradation a complex discipline to research (Higginbottom and Symeonakis, 2014). Even in small-scale applications, investigations are challenging since land degradation is heterogeneous even within the same landscape (Nyssen et al., 2009).

While the above-mentioned elements reveal the theoretical complexity of land degradation, additional challenges emerge when land degradation is studied with respect to a specific context. As part of the Mediterranean region, Lebanon displays the classical Mediterranean unequal division of land use/cover classes between mountainous and coastal parts (D'Ostiani, 2004). Generally, land occupation dynamics in Lebanon are translated by conversions from natural covers to artificial classes, or shifts within the same classes to different land uses (Foley et al., 2005). As in other Mediterranean contexts, the abandoning of extensive agriculture and grazing lands (Vinograd et al., 2019) in some areas, with concurrent intensification of agriculture in others (Serra et al., 2008) under inherited and conventional knowledge (Hudson and Ayala, 2006), are also common features of the country's landscape.

Lebanese lands have long been under pressure due to intrinsic topographic factors (64 per cent of the country has steep slopes) and increasing human activities that resulted in widespread land degradation (Darwish, 2012). The oldest form of anthropogenic-induced land degradation in the country follows from land use/cover changes such as deforestation and the removal of green cover (Darwish et al., 2004). From the 1950s onwards, chaotic urban growth and population expansion into prime lands (World Bank, 2019a) have further worsened land degradation (Darwish et al., 2012). Land use/cover change occurred at a rapid rate, particularly in the country's narrow coastal stretch (Darwish et al., 2004). Most of these changes were uncontrolled urban expansion on agricultural, forested, and natural cover (Masri et al., 2002). Excessive displacement from rural to coastal areas brought on adverse impacts to both contexts. Consequently, rural areas suffered from land abandonment and induced land degradation, while coastal areas had to deal with increasing urbanization, loss of green cover and increasing resource pressures (Masri et al., 2002).

The current LU/LC of Lebanon is the result of the long Lebanese crisis (1975–1990), dominated by complex internal and external unrests, successive periods of wars with neighbouring countries, civil war, uncontrolled resource exploitation, and the absence of regulations and legislative controls (Masri et al., 2002). Even in modern days, land tenure is poorly addressed in the country, where state-classified lands total only 10 per cent, leading to continuous uncontrolled exploitation of unclassified lands which often are green natural areas (Darwish, 2012). According to recent studies, agricultural and natural spaces are still declining as a result of uncontrolled urbanization, lack of governance, poor land stewardship, and the absence of management plans (Verdeil et al., 2016).

As mentioned previously, several studies have investigated land degradation during post-war episodes in Lebanon, but very few have reviewed the effect of recent events (2011–2020). While the transformations of 1990s are still occurring in the country, the events presented below compounded the situation.

Event	2011	2012	2013	2014	2015	2016	2017	2018	2019	2020
Syrian crisis spillover	high	high	high	high	mid	mid	mid	low	low	low
Geopolitical tensions	high	high	high	high	high	high	high	high	high	high
Local political unrests	mid				mid	mid			high	high
Internal clashes		low	mid				high			
Terrorism				high	high	high	high		low	
Waste disposal system collapse					high	high				mid
Economic crisis									mid	high
Wildfires				low		mid			high	mid
COVID-19 and Beirut Port explosion										high

Legend: high, mid, low

Table I: Key recent events in Lebanon and their level of impact

At a first glance, many of these events might not appear directly related to land degradation. However, the literature review presented in the following section and the analysis of the results reveal that their effects might actually be stronger than those of the previous periods. This is due to the prevalent socioeconomic-political constraints (Khater et al., 2012), and the lack of focus on environmental welfare (Khater et al., 2003) that characterize Lebanon. Efforts have been made by several UN agencies, bodies and local institutions for restoring Lebanese lands; however, scientific research on land degradation is still needed. While Lebanon's situation continues to deteriorate, tackling a complex discipline such as land degradation is a must for understanding land health and focusing efforts on food production (Mohtar and Assi, 2018).

1.2 The land degradation model: adapting land degradation indicators for national and regional applications

As previously mentioned, land degradation is contested in its definitions, determinants, and causal factors (Al-Sayah et al., 2019a). The different definitions of land degradation come from different points of view. Accordingly, what might be a degraded land for a farmer does not necessarily mean the same for an engineer, a geomorphologist or an ecologist. Since different perceptions of land degradation exist, a clear separation between degraded and non-degraded lands cannot be established, i.e. there are no unified guidelines for representing or mapping land degradation (Safriel, 2017). Consequently, differences of perspectives lead to split decisions regarding the willingness to adopt or adapt counter-degradation measures (Assefa and Hans-Rudolf, 2016). Nonetheless, given the importance of holistic representations of land degradation for accurate future interventions, the most common driving forces of land degradation were integrated as indicators in this study. In this way, the different definitions of the process would be taken into consideration, hence minimizing the risks of wrongly estimating land degradation.

Indicator 1. The expansion of urban cover and informal settlements over different land capability classes: This indicator was divided into two sub-indicators: 1.1. Lebanese urban cover expansion, and 1.2. Informal settlements and practices. The logic behind this division is justified by several reasons.

Sub-indicator 1.1. Lebanese urban cover expansion: As was described in section 1.2., urban expansion in Lebanon occurred without restraints and any consideration of land potential (Darwish et al., 2004; Verdeil et al., 2016). Accordingly, a very considerable fraction of urban development occurred over the country's potent lands. The absence of urban planning schemes and faulty decisions, such as municipal rights providing construction permits, exacerbated the unplanned expansion. While urbanization is unavoidable for housing the growing populations (Wang et al., 2018), urban expansion happens at the expense of natural or agricultural classes. The direct relationship between urbanization and land degradation is well established (Ferreira et al., 2018). Additional indirect effects resulted from decreasing interests and contact of humans with soils, due to the misconception of the urban society's disconnection to soils, in contrast to the rural society's dependence (FAO and ITPS, 2015). In the Arab world, urbanization rates are very rapid (Hussein, 2016). According to AbouKorin (2011), the urban population in the Arab world was expected to increase from 56 per cent in 2001 to 66 per cent in 2020. Given the direct relationship between land degradation and urbanization, the urban expansion sub-indicator was integrated.

Sub-indicator 1.2. Informal settlements and practices: According to Nassar and Elsayed (2018), the expansion of informal settlements places a burden on many developing countries. Berry (2008) reports that the UNHCR, the scientific community, and refugee-related organizations have increasingly acknowledged the role of refugees in causing environmental degradation and depleting resources, both in and around informal settlements. Informal settlements often expand on lands of considerable productive capacity (Aguilar and Santos, 2011), compounding the increasing demand for resources (Martin, 2005). Additional pressure is exerted by settlement daily life practices (sewage, sanitation, water consumption, etc.), which are often detrimental to the environment (Hansen et al., 2005). Both the competition for resources and settlement practices fuel environmental and socioeconomic conflicts between host communities and displaced populations (Martin, 2005). In the case of Lebanon, Diab et al. (2020) attributed the development of informal settlements to several factors: (1) governmental inaction regarding the regulation of urban expansion and strategic developments; (2) the civil war and post-conflict instability induced rural displacements; (3) massive displacement waves of foreign working forces and refugees; (4) the absence of a national public transport sector; and (5) the dependence of Lebanon's economy on the real estate and service sectors. Incapable of paying rents, most of the displaced Syrian populations live in tent settlements throughout the country (Tinas, 2017). Most of these settlements are considered informal since the Lebanese government refused the creation of official refugee camps by humanitarian parties (Diab et al., 2020) and because some displaced populations illegitimately occupied lands or properties (ILO, 2014). While most of the displaced populations are concentrated in Lebanon's most burdened areas (Tinas, 2017), the expansion of informal settlements along with their associated practices added another layer of complexity on the country's already precarious situation and burdened lands (IOM and UNCCD, 2019), hence, the inclusion of this sub-indicator.

For clearly revealing the effect of urbanization on the underlying lands, land capability classification was embedded within indicator 1. The logic behind this approach is to reveal above which land classes urban and informal settlement expansion has occurred, in order to examine Aguilar and Santos' (2011) hypothesis regarding the expansion of urban settlements over lands of high potential. Furthermore, insights on the Lebanese urban cover's suitability with respect to land potential would be offered.

Indicator 2. Population change: This indicator is one of the most obvious drivers of land degradation. Population increase is a well-documented land degradation driving force, considered as the primary cause of environmental degradation when it exceeds the system's support threshold (Ferreira et al., 2018; Zaman et al., 2011). Humans have long adapted lands to their needs and have brought considerable modifications to the Earth's surface since the 1760s industrial revolution (Li et al., 2017). With a projected global population increase from six to nine billion people by 2050, most of the Earth's lands will be needed to feed these growing numbers (Van Schaik and Dinnissen, 2014). Nonetheless, ongoing degradation puts a strain on land for sustaining and supporting human livelihood much greater than what is available (Erdogan et al., 2019). According to UNCCD (2017b), 1.3 billion people in developing countries are trapped on degrading or already degraded lands. The Arab region houses a considerable part of the world's population, which is growing rapidly (Tabutin and Schoumaker, 2005). According to Mirkin (2010), the population of the Arab countries has tripled since 1970, going from 128 to 359 million, and is forecast to reach 598 million by 2050.

As part of the Arab region, and despite its small size, Lebanon hosts the highest number of refugees per capita globally (UNHCR, 2020). Prior to hosting refugees, Lebanon was an already densely populated country characterized by high rates of internal displacement, outmigration, and a worldwide diaspora. The country is an important destination for migrant workers in various sectors, causing additional population surplus. As of 2014, Lebanon hosted the highest number of refugees per 1,000 inhabitants; by 2015, one out of four residents was a displaced Syrian individual (Diab et al., 2020; Kelley, 2017). In an already crowded country that did not sign the 1951 UN Convention on the Status of refugees and in the absence of specific laws and frameworks related to these issues (Tinas, 2017), displacement waves shocked the Lebanese system and environment (Kelley, 2017). Despite the well-established relationship between migration and land degradation (McLeman, 2017), the adopted policies and efforts did not fully consider the Syrian displacement–induced land degradation (IOM and UNCCD, 2019). Since May of 2015, the UNHCR ceased the registration of incoming displaced populations upon demand of the Lebanese government (Tinas, 2017), for Lebanese and Syrian political/national security reasons. Accordingly, there is no updated official number as pressures on livelihood are escalating for the displaced populations, host communities and the country as a whole (ILO, 2014). With ongoing transboundary displacement, migrating populations fleeing from conflict are causing active competition with host communities, initiating and exacerbating land degradation (McLeman, 2017). With the current situation of Lebanon, high population growth rates coupled with decreasing per capita income will only worsen environmental degradation (Zaman et al., 2011). Several UN bodies and agencies, namely UNHCR and UN-Habitat, stepped in to assist Lebanon with this situation. Numerous studies investigated the socioeconomic impact of Syrian displacement waves into Lebanon but only a few focused on the biophysical aspect (Jaafar et al., 2019). To address this gap, the population change (residents and non-residents) index, together with indicator 1.2 were investigated. Both indicators 1.2 and 2 overarch across other elements of this study, namely indicators 3, 5, 6 and 8. Therefore, indicators 1 and 2 can be considered as powerful modifiers of the Lebanese context, as both are active and rapid agents of land degradation (Ferreira et al., 2018). Sub-indicator 1.2 and indicator 2 can also be modified to fit the Jordanian context, since Jordan is ranked second after Lebanon in density of refugee populations per 1,000 residents (Diab et al., 2020).

Indicator 3. Abandoned agricultural lands and land capability classes: The complexity of land degradation and its cross-cutting nature make it difficult to map land degradation (Prince, 2002). According to Gibbs and Salmon (2015), monitoring abandoned agricultural lands is a frequently used approach to assess land degradation. Agrarian abandonment is very common in the Mediterranean (Cerdà et al., 2018), seen as the most widespread change to occur over the last centuries (Novara et al., 2017). Numerous reasons lead to agrarian abandonment. According to Khanal and Watanabe (2006), the most evident causes are the decline of economic revenues that drive farmers to search for more profitable occupations. Other factors include market challenges, rural displacement, reduced land productivity, land tenure policies, political-legislative factors, and intrinsic properties such as climate and topography (Benayas et al., 2007; Lesiv et al., 2018). Agrarian abandonment impacts lands in numerous ways: considerable changes of soil quality (Van Hall et al., 2017), reduced capacity to provide eco-services, social landscape modifications, increased soil exposure to erosive forces and devaluation of land-based capital (Chaudhary et al., 2019). Other implications include threats to food security (Meyfroidt et al., 2016), providing biofuel for wildfires (Moreira and Pe'er, 2018), and increasing the frequency and intensity of geomorphic hazards (Chaudhary et al., 2019).

Several of these factors are applicable to the case of Lebanon. Accordingly, revenues from agricultural activities are low; market competition with foreign merchandise is very prevalent; land properties are deteriorating, and the temporary closure of Syrian borders influenced Lebanon's agricultural land transportation chain (exports) to Arab markets. Agrarian abandonment is one of several land-related challenges. In the absence of state protection of national agricultural production through customs' fees (in the name of liberalism), continuous pressure on the Lebanese government from food-exporting countries further complicates the situation.

According to Gibbs and Salmon (2015), mapping abandoned agricultural lands allows visualization of changes rather than providing estimates or assumptions. For that purpose, Lebanon's abandoned agricultural lands were chosen as a national indicator of land degradation. However, according to the same authors, this mapping technique might include lands that are not degraded, thereby leading to questionable representations of land degradation. To account for this point, this study investigated the occurrence of abandoned agricultural lands over different land types, along the following logic:

i) Determine where agrarian abandonment is causing land underuse (lands being used less than their potential). Land underuse was targeted since it constitutes a form of loss in land productivity (Stocking, 2001), which in turn implies land degradation.

ii) Determine where abandoned agricultural lands should be planted again to halt land underuse, and where agricultural lands should be afforested/revegetated to reduce soil loss risks and recharge land capital.

iii) It is important to mention that indicator 3 positions agrarian abandonment as both a cause and consequence of land degradation. The Arab region is the world's leading food importer as agricultural activities are hampered by prolonged droughts, a harsh climate, desertification and scarcity of water resources (Woertz, 2017). Therefore, optimizing the agricultural sector is key for ensuring food security, and hence the importance of this indicator.

Indicator 4. Quarry cover expansion with respect to land capability classes: Intensive quarrying activity accompanied the urban boom of Lebanon after 1990 (Verdeil et al., 2016). As in other regions of the world, quarrying activity damaged previously natural areas (Tsolaki-Fiaka et al., 2018) and caused extensive land modifications (Darwish et al., 2011). Quarries are well- documented sources of biodiversity destruction (Lameed and Ayodele, 2011), landscape alteration (Tsolaki-Fiaka et al., 2018), soil and land degradation (Baah-Ennumh et al., 2019; Chenot et al., 2018), pollution (Pal and Mandal, 2019), and soil erosion/landslides (Abdallah, 2011). In Lebanon, unregulated quarrying activity substantially damaged its natural capital (World Bank, 2019a). Most of the quarry cover's expansion occurred at the expense of forests and productive arable lands (Darwish et al., 2011). Darwish et al. (2008) attributed this development to the poor institutional and political frameworks of the country that led to an unregulated expansion. Accordingly, Darwish et al. (2011) reported that 62 per cent of Lebanon's quarries were in highly inadequate environments with respect to land capability. Between 1989 and 2005, the number of quarries expanded from 784 to 1,278, almost doubling the total area (Darwish et al., 2011). Therefore, quarry cover expansion was considered as an indicator in this study. In analogy to the work of Darwish et al. (2011), the areas of quarried zones and their occurrence with respect to the different land capability classes were monitored.

Indicator 5. Conflicts and exceptional events: The literature refers to food and water scarcity, climate change and resource availability as environmental causes of insecurity, often leaving land degradation out of the equation (Van Schaik and Dinnissen, 2014). This aspect is problematic since fertile and healthy lands are needed to address the above-mentioned phenomena (Çelik and Akça, 2019). Land and conflicts are closely entwined; often lands or land-related issues are either the main causes or the primary driving forces (United Nations Interagency Framework Team for Preventive Action, 2012). The role of land in conflicts is gaining increased international interest due to the evolution of armed conflicts, their nature and long duration (United Nations Interagency Framework Team for Preventive Action, 2012). The term conflict encompasses a wide range of phenomena such as wars, violent acts, protests, riots, terrorism and assassinations (Van Schaik and Dinnissen, 2014). When conflicts happen, direct and indirect manifestations are observed: the direct effects are visible at the landscape scale, while the indirect effects are translated by modifications of the environment (Mubareka and Ehrlich, 2010). Armed conflicts and wars are some of the most dramatic causes of environmental degradation by biological, physical and chemical soil disturbances (Certini et al., 2013), and soil damage induces land degradation (Kertész, 2009). Furthermore, armed clashes inflict irreversible or irrepressible socioeconomic damages to agriculture, land use and land cover (Hamad et al., 2018).

Most violent conflicts – if not all – involve lands (USIP, 2007). With subsequent changes in the socioeconomic-political equilibrium, land-related tensions can easily shift to violent acts (Bruce and Holt, 2011). The most prominent example from the Arab world is the Israeli-Palestinian conflict, where continuous disputes on lands have been occurring since 1948. The importance of lands comes from their economic, political, strategic and cultural values, as eager governments seek to control them to ensure economic development and establish national security (Bruce and Holt, 2011).

However, the ongoing demographic expansion, climate change, environmental degradation and land use/cover changes are increasing demands on lands and subsequent competition for resources (Olsson et al., 2019). As a result, resource-based conflicts are thriving (Hartard and Liebert, 2015). Gleditsch (2015) summarized these elements into the following causal chain: increasing population and subsequent resource competition per capita, more intense environmental degradation, higher resource scarcity, higher resource competition, elevated risks of violence. Despite these facts, the research on the impact of armed conflicts on land use/cover decision-making, and hence land use/cover patterns, is still in embryonic stages (Baumann and Kuemmerle, 2016).

While shocks have the potential to disrupt the normal functioning of land systems, the related knowledge is still limited (Baumann and Kuemmerle, 2016). This is unfortunate, particularly in the case of the Arab region where shocks are quite frequent. According to the Stockholm International Peace Research Institute (SIPRI) (2012), the Middle East and South Africa are the least peaceful contexts of the world as they are characterized by frequent political unrests. Alvarez (2003) and Davalos (2001) found that political instability led to increased deforestation and promoted land degradation in populated areas. In the case of the Arab world, rural lands are already scarce, and the expansion of cities reduces the availability of surrounding lands, restricting food production capacities and elevated food import rates (FAO and ESCWA, 2017). As a result, food security in the Arab region is unstable, as it is highly dependent on imports. While a direct relationship between food security and conflicts exists (Raleigh et al., 2015), land degradation through its various effects worsens this vicious cycle.

In Lebanon, violent conflicts have shaped the history and the present of the country (Bellal, 2018), and fears of new ones haunt its citizens. In addition to direct internal and external conflicts, Lebanon suffered the weight of several neighbouring wars. Accordingly, the Israel-Palestinian conflict put a heavy burden on Lebanon through Lebanese-Israeli conflicts and subsequent Palestinian refugee influxes. As discussed in the previous indicators, Lebanon was recently also hit with the fallout of the Syrian crisis. With a weak institutional framework, delicate political situation and social inequalities, Lebanon is intrinsically prone to conflict and violent episodes (United Nations Interagency Framework Team for Preventive Action, 2012). With time, these elements caused acute biophysical modifications to the environment (UNDP, 2007), namely those listed in section 1.2.

Conflicts often result in excessive migration and population displacement (O'Malley, 2018). Massive displacement waves (see indicator 2) and their induced urbanization (see sub-indicator 1.2) are a common hidden strategy in modern conflicts. It is a form of "justified" territorial overtaking that serves as a pressuring factor on host states and implicated international parties (United Nations Interagency Framework Team for Preventive Action, 2012). While lands are impacted by conflicts, they can also initiate, sustain or promote conflicts (USIP, 2007). There is evidence that governments and the international community are more engaged in addressing the land-conflict nexus (United Nations Interagency Framework Team for Preventive Action, 2012). However, more efforts on this topic are needed in Lebanon. Van Schaik and Dinnissen (2014) reported that land degradation, food and water scarcity, rapid population increases, migration, bad governance and reduced socioeconomic conditions are causal factors of conflicts. Transposing these observations to Lebanon, much can be expected when indicators 1, 2, 3, 4, 6 and 8 are considered.

Indicator 6. Land use and land cover changes: The land use/cover description of Lebanon was presented in section 1.2. As can be deduced, most of the described changes occurred without considering long-term sustainability or accounting for land suitability (Darwish et al., 2004). This led to major stress on natural resources, particularly on lands and soils, whose quality and productivity declined as a result of continuous mismanagement (Al-Sayah et al., 2019b). According to Darwish et al. (2004), land use/cover changes are the primary cause of land degradation in Lebanon.

The importance of the land use/cover indicator for land degradation studies is how representative it is of land surface changes as well as its reflection of human modifications to the natural system (UNCCD, 2016). According to Gabriels and Cornelis (2009), the most damaging LU/LC changes are deforestation, overgrazing, overexploitation of vegetation cover, agricultural mismanagements and industrial (urban) expansion – all are prevalent in Lebanon. In the Arab region, rangeland mismanagement and the cultivation of agricultural lands are common in North Africa, while the overexploitation of land resources characterizes the Middle East (ESCWA, 2016). Since land use/cover change is both a cause and consequence of land degradation, this index reaches across the other seven study indicators. Accordingly, the relationship between LU/LC changes and the study's indicators is bidirectional and can be considered as a cause-consequence nexus. Therefore, land use/cover was integrated as an indicator.

In addition to land use/cover changes, climate change is one of the main drivers of land degradation (Ioras et al., 2014). Its effects are accounted for within indicator 6; however, this indicator should be better developed in studies where sufficient climate data is available.

Indicator 7. Wildfires: Several natural hazards cast their weight over Lebanon, see Abdallah et al. (2018) for a detailed review; however, during the period covered by this study, wildfires were the most frequent one. Wildfires are common disturbances in the Mediterranean ecosystems (Versini et al., 2013) and are considered as some of its most alarming (Ferreira et al., 2008). With time, their frequency, spatial coverage and intensity has been increasing (Efthimiou et al., 2020), due to the climatic setting of the Mediterranean region and its intrinsic properties that facilitate the outbreak of wildfires (Vieira et al., 2018). Scientific studies have provided solid evidence regarding the role of climate change in exacerbating the outbreak of fires (Neary, 2009). In the case of the Mediterranean climate, these effects can be attributed to considerable vegetation growth during wet seasons that provides hefty biofuel for the hot and dry summers (Esteves et al., 2012). However, in the Arab Mediterranean region. the climatic effect is surpassed by the intentional use of fire for land clearing, increasing neglect, and more frequently arson fires in conflict laden countries such as Algeria (FAO, 2010) and more recently also Lebanon. The Lebanese government together with other actors has already invested in early warning systems; however, the main problem lies in the response phase, as firefighting is the mandate of the Lebanese Civil Defense, that has very limited manpower and equipment resources.

Additional causes for the prevalence of wildfires can be attributed to the land use/cover dynamics and the rapid urban development that led to the expansion of wildfire-urban interfaces (Mallinis et al., 2009). However, most wildfires occur in grass/shrublands (Jolly et al., 2015), forests (Abdallah, 2019), and agricultural zones (Pearson et al., 2016). Consequently, wildfires are considered some of the most active modern day land degradation driving forces (Esteves et al., 2012) as they severely reduce vegetative covers (Mallinis et al., 2009). Wildfires also push soil erosion rates above the thresholds of irreversibility (Neary, 2009), promote desertification (Neary, 2018), and cause the loss of ecosystem productivity (Bowman et al., 2009). Despite their deleterious effects, when wildfires occur in natural-logical manners, fire-ecosystem regeneration, reduction of biofuels, and the promotion of ecosystemic dynamic health are ensured (Keane et al., 2008). Nonetheless, when wildfires become repetitive, the opposite effects are observed.

Through the destruction of topsoil vegetation layers, wildfires reduce the soil's protective cover (Durán Zuazo et al., 2008) and weaken root-soil stability (De Baets et al., 2007). These factors increase soil exposure to erosive factors (water or wind) (Liu et al., 2017) and subsequently accelerate post-fire soil erosion (Vieira et al., 2018). In a region characterized by fragile pedology (Darwish et al., 2018), burning damages encompass the following: loss of soil organic matter; modification of soil water repellence, structure and stability (Stavi, 2019); nutrient loss and damage to the soil's biology (Certini, 2005). According to Neary (2009), soil loss by degradation or erosion is irreversible as lost soils can be rehabilitated to some extent, but not restored. Nadporozhskaya et al. (2018) showed that a single wildfire event in a mature Scots pine forest led to significant, long-term (40 to 50 years) losses of net primary productivity. Since wildfires occur on the topsoil and its corresponding cover, soil organic matter is severely damaged in terms of quantity and quality (Nadporozhskaya et al., 2018; Stavi, 2019). Hence, the status of wildfires as potent agents of land degradation. The consequences of recurrent wildfires on land degradation are analogous to those of soil erosion, through the loss of soil Carbon and Nitrogen (Nadporozhskaya et al., 2018). Accordingly, since soil erosion is considered one of the most amplified biophysical forms of land degradation (Dooley et al., 2015; ELD Initiative, 2013), wildfires as drivers of soil erosion, cannot be disregarded in land degradation studies.

The direct consequences of wildfires make them potent threats to sustainable development and environmental well-being. However, long-term consequences such as accelerated land degradation rates in burnt areas (Esteves et al., 2012) make wildfires threatening events with short- and long-lasting repercussions. According to Bajocco et al. (2010), land degradation and fires are linked by directly proportional relationship. While land degradation increases the context's susceptibility to fires, fire outbreaks aggravate land degradation. Under particular circumstances, land degradation may create conductive pathways for fires to proliferate, which if repeated, may plunge the affected context into a land degradation–fire feedback loop (Bajocco et al., 2010).

In relation to land use/cover, unsuitable management of forests and agrarian abandonment aggravate fire hazards (Hirschberger, 2016). Knowing that the most important input for fires is the fuel load's quantity (Stavi, 2019), agrarian abandonment causes a dissymmetric accumulation of biomass that can fuel fires (Mantero et al., 2020). Consequently, land abandonment leads Mediterranean forests into different fire dynamics (Ursino and Romano, 2014). Considering what was presented in this section and given the frequent occurrence of wildfires in Lebanon and other Arab countries with Mediterranean climates, wildfires were chosen as indicators of land degradation in this study.

Indicator 8. Socioeconomic parameters: Socioeconomic and political constraints have caused sharp differences in the perception and adaptation measures to environmental challenges in the Mediterranean region (Khater et al., 2012). Socioeconomic, sociopolitical and sociocultural factors are considered powerful indirect driving forces that push people to degrade the environment (Abu Hammad and Tumeizi, 2010). For holistic representations of land degradation and accurate restoration strategies, both biophysical and socioeconomic indicators should be investigated (Vu et al., 2014). In recent years, socioeconomic developments have been considered as a primary underlying factor of vulnerability to land degradation (Salvati et al., 2011). When considering the socioeconomics of land degradation, both the social and economic components must be examined. According to Iosifides and Korres (2002), social policies are key elements for coping with land degradation, while economic policies are some of the major factors that govern sustainable development. To become sustainable, any form of production activity should be economically viable (Iosifides and Korres, 2002). This is particularly the case of the agricultural sector, with the link between land degradation and decreasing agricultural yields (Nkonya et al., 2008).

Anthropogenic-induced land degradation is mainly due to the interactions between lands and users of different socioeconomic statuses (Erdogan et al., 2019). While some interactions are harmless, others cause considerable environmental disturbances (Chukwu, 2008). Given the differences in socioeconomic statuses, different degrees of environmental disturbances are expected. However, a particularly intricate relationship arises in the case of poverty and environmental degradation (Nkonya et al., 2008). The term poverty is debated, as it possesses several dimensions and does not necessarily mean poverty of income or reduced material well-being (Etongo et al., 2016).

Through its negative effects on land productivity and eco-services provision capacity, land degradation aggravates environmental and social vulnerabilities (Gerber et al., 2014). As a result, the most vulnerable socioeconomic classes are often the most susceptible to the impacts of land degradation (Darwish et al., 2012). Accordingly, more than half of global land degradation occurs in the world's poorest countries (UNCCD, 2015b). While increasing poverty or reduced socioeconomic capacities are simultaneously causal and consequential factors of land degradation (Iosifides and Korres, 2002), they are primary concerns to people since they directly influence land capital–based services and their associated benefits (Sutton et al., 2016).

The significance of eco-services is best explained when these services are translated into beneficial goods and services such as food, water, recreation, energy and others (Gerber et al., 2014; Mohtar and Lawford, 2016). With land degradation, these services are directly affected, and as a result, the land's economic value declines (ELD Initiative, 2015). Consequently, land abandonment becomes more prevalent and in turn leads to more aggravated land degradation. This spiralling relationship increases poverty, reduces communal/natural resilience and widens inequality gaps across communities (UNCCD, 2019). As a result, the often-costly land management methods are ignored, while promoting the unsustainable conventional practices (Hudson and Ayala, 2006).

However, there is no general agreement on the nature or type of socioeconomic determinants associated with land degradation, particularly in the Mediterranean region (Mairota et al., 1998). According to Briassoulis (2004), the socioeconomic indicators of land degradation should cover demographic, productive and political factors. In order to obtain the most informative insights, the following indicators were integrated: economic capacities, trade balance, GDP growth, unemployment rates, food prices, household income levels (cf. integrated in indicator 1.2), and population increase (cf. indicator 2). These factors were chosen for their cultural, political, and socioeconomic aspects, as well as because they mediate the relationship between populations and the environment (Zaman et al., 2011). Consequently, through the integration of these elements as representative of socioeconomic indicators, more inclusive land rehabilitation/restoration plans can be obtained. In turn, the latter could reverse socioeconomic downfalls and mitigate poverty (UNCCD, 2019). It equally important to recommend the integration of data or information on state policies vis-à-vis these elements. However, in the case of Lebanon, this information is still missing despite the state's willingness to act.

It is also important to mention that socioeconomic indicators are not uniform, and should be carefully chosen with respect to the characteristics of each context. This is due to the fact that the relationship between socioeconomic elements and environmental degradation is not universal and is governed by site-specific attributes.

1.3 Objectives

In light of the review of issues and approaches relevant to the case of Lebanon, the objectives of this research are the following:

1. Establishing a set of inclusive land degradation indicators;

2. Proposing a general holistic framework for the assessment of land degradation;

3. Providing an updated review of national land degradation in Lebanon;

4. Addressing several key relationships and elements: land and conflict; land and natural resources; land and socioeconomic development; urbanization, planning and development control; land-based investments and land planning policies and regulations.

CHAPTER TWO: STUDY AREA DESCRIPTION

Lying on the eastern coast of the Mediterranean Sea, Lebanon (officially known as the Lebanese Republic) is at the heart of the Arab world (see Figure I). Extending over 10,452 km², between 33.8547° N and 35.8623° E, Lebanon is the second smallest country in the Middle East. Its geographic position granted the country strategic importance as the crossroads between the Western and Arab worlds. Given its proximity to the Mediterranean Sea, Lebanon displays a typical Mediterranean climate (Trærup and Stephan, 2015). Due to the country's unique geographical location, characteristic coastal strip topography and the two mountain ranges (Lebanon and Anti-Lebanon) surrounding an inland Bekaa plateau, it experiences all four distinct seasons (Farjalla et al., 2014). With a highly heterogeneous topography, Lebanese slopes range from 0 to 88 degrees, while altitudes extend between 0 and 3,109 metres. The particular topographic and climatic settings made the country an exception in terms of land and climate in the Arab region (Al-Sayah et al., 2019).

A classical Mediterranean land use/cover pattern, characterized by an uneven distribution of land occupation classes between the mountainous and coastal areas (D'Ostiani, 2004) defines the country's landscape. According to Darwish et al. (2006), thirteen soil groups and 106 soil units (predominantly calcareous) are documented. Administratively, Lebanon is divided into eight governorates, 26 districts, and 1,627 cadastral units, which in turn encompass one or several villages (OCHA, 2017). Lebanon is home to more than six million inhabitants (Government of Lebanon and United Nations, 2019) mostly concentrated in the Mount Lebanon governorate (CAS, ILO and the EU 2020). Most of Lebanon's economic activity is concentrated in Beirut, the country's capital.

Figure I: Geographic location and administrative structure of Lebanon.

This study provides an updated review of recent events in Lebanon and their relationship with national land degradation. First, a compilation of various data sources, an in-depth review of relevant studies from published and grey literature and a bibliographic review were performed. Following this step, an updated inventory was built, and the resulting outcomes were compared against baseline conditions. Given the multidisciplinary nature of the approach, several datasets were adopted, while others were built. Each element of this study's workflow was built using replicable methods from readily available data sources. The logic behind this approach was to extend the use of the presented methods and indicators beyond the national scale, thereby providing a robust tool for application in other Arab and Mediterranean settings.

3.1 Materials and datasets

According to the World Bank (2009), Yemeni law, both statutory and sharia, recognizes certain fundamental land tenures, each with its own legal definition and distinctive rules. These are state land, private ownership, religious endowments, communal ownership and tenancy. According to the Public Land Management Policy Paper, Land Equity International (2010), there is another land classification as follows:

Dataset	Source	Characteristics	Used for
Land use and land cover map of Lebanon 2013 and 2017	(Faour and Abdallah (2013, 2018	spatial resolution 1:20,000 Validated by field surveys	Indicators 1, 3, 4 and 6
Informal settlements 2016	(IAMP and UNHCR (2016	Updated vector map of the informal settlements' characteristics and distribution	Indicator 1
Land capability classification map	(Darwish et al. (2005	Obtained from the combination of several layers: topography and soil .physical/chemical characteristics	Indicators 1, 2, 3, 4 and 6
Population data 2020	(CAS, ILO and EU (2020	Updated labour force and household survey	Indicator 2
Quarry cover and 2018 ,2017 ,2013 2019	(Faour and Abdallah (2013, 2018 CNRS-RSC aerial photographs	Distribution of quarry and mineral extraction sites	Indicator 4
Conflicts and exceptional events 2020–2011	ACLED database (Raleigh et al. (2010	Real-time geolocalized recordings of events' locations, dates, actors, fatalities, and types of all reported political violence and protests	Indicator 5
Wildfire maps of Lebanon 2016–2020	CNRS-RSC	Real-time geolocalized recordings of wildfires' locations and associated damages	Indicator 7
Socioeconomic data	(World Bank (2020	Historical and present socioeconomic parameters monitored by the World Bank	Indicator 8

Table II: The datasets used in the study and their characteristics

Methodological insights

Most of the available national data was obtained from the CNRS-RSC, the scientific arm of the government. Accordingly, one of its several missions is to build and update national databases. However, since this study aims to present an applicable tool in other Arab or global contexts, the following global data sources are proposed for building the indicators:

- Land use and land cover maps:

Copernicus CORINE land use/cover maps: https://land.copernicus.eu/pan-european/corine-landcover#:~:text=It%20consists%20of%20an%20inventory,an%20MMU%20of%205%20ha
MODIS land cover maps: https://www.visibleearth.nasa.gov/images/61004/new-land-cover-classification-maps

- Soil data and attributes (land capability classification)

The FAO's digital soil map of the world: http://www.fao.org/land-water/land/land-governance/land-resources-planning-toolbox/category/details/en/c/1026564/

- Topographic data

The Space Shuttle Radar Topography Mission (SRTM): https://earthexplorer.usgs.gov/

- Population and socioeconomic data

The World Bank dataset: https://data.worldbank.org/country

- Forest fire data

NASA's Active Fire data: https://earthdata.nasa.gov/earth-observation-data/near-real-time/firms/active-fire-data

3.2 Building the indicators

Each indicator was built using a specific, detailed approach. The built indicators were then integrated into a GIS environment (ArcMap 10.3) to setup the study's framework. Despite its number as indicator 6, land use/cover maps were the basis of this study. All the indicators were derived from these maps. Indicator 6 was obtained by on-screen digitizing multispectral satellite images of different acquisition dates (2013: GEOEYE images, 0.5 m; 2017: SPOT images, 1.5 m). The maps were then classified following the Lebanese adapted Coordination of Information on the Environment (CORINE) land use/cover nomenclature. The remote sensing findings were then validated through field surveys using the ArcGIS Collector application (Esri, 2018).

Indicator 1: Urban classes and informal settlements were extracted from the land use/cover maps, while additional data on informal settlement and their distribution were extracted from the IAMP and UNHCR (2016). These dataset was utilized given its detailed content, including the count of informal settlements and related practices. Then, the urban cover and informal settlements layers were intersected with the land capability classification map using ArcGIS' 10.3 Intersect Tool (Esri, 2016). This step was performed to study the distribution of informal settlements and urban classes over the different land capability classes and examine the pressure placed on lands.

Indicator 2: This indicator was built using the CAS, ILO and EU's (2020) report on labour force and household living conditions. The data was aggregated and attributed to each governorate and district.

Indicator 3: Abandoned agricultural lands were extracted from the land use/cover maps of each studied year. Similarly to indicator 1, this layer was intersected with the land capability classification map to determine if these occupy prime (i.e. land underuse leading to land degradation) or non-arable lands (i.e. suitable distribution that can be further optimized).

Indicator 4: Mineral extraction sites were equally extracted from the land use/cover maps for the years 2013 and 2017. For the years 2018 to 2019, aerial photographs issued by CNRS-RSC were used. Similarly to indicators 1 and 3, the land capability classification layers were used as a base map to determine the distribution of quarries over the different land classes. Subsequently, quarrying induced land degradation was inferred.

For indicators 1, 3, 4 and 6, land capability classification was used to obtain an informative decision tool regarding the adequacy of the current cover with respect to the land's potential. The land capability classification layer also served as a data-based decision tool to orient future land use planning. That way a comprehensive restoration plan for degraded lands ensuring the highest environmental and socioeconomic benefits can be built.

Indicator 5: The ACLED and PRIO datasets were transformed into vector format (ArcGIS shapefiles) and categorized by event per governorate. Each event was then analysed and conflict profiles at the national and governorate scales were built.

Indicator 7: Wildfires data, along with their associated damages were obtained from the CNRS-RSC wildfire database.

Indicator 8: Socioeconomic data was compiled from the World Bank database for country profiles and from the CAS, ILO, and EU (2020) report. Several parameters were then extracted, based on their direct or indirect relationship with land degradation. The chosen parameters were unemployment data, income data, GDP, GDP per capita, Lebanon's economic crisis data, and trade balance (imports versus exports). Additional data on the COVID-19 outbreak and the Beirut blast was obtained from various data sources.

Finally, the relationship of each indicator with land degradation was studied and corresponding recommendations were made. Since land degradation is driven by socioeconomic and biophysical factors (Vu et al., 2014), the presented methodology provided a holistic framework by combining these factors as indicators.

In this section, the findings from the review of recent events in Lebanon are linked to land degradation. The results of each indicator, their significance and implications are analysed in detail in this chapter.

4.1 Indicator 1: expansion of urban cover and informal settlements over different land capability classes

Since urbanization in Lebanon is often unplanned and unrestricted, urban expansion over different land capability classes is not surprising. The multiplication of these urban classes is a direct consequence of demographic expansion; however, the trade-off between constructing housing and conserving natural resources has been skewed for some time. Due to the sudden demographic changes brought about by the Syrian crisis, more housing had to be provided. As reported by Nassar and Elsayed (2018), the expansion of urban settlements occurs mostly in agricultural lands. To determine if this logic applies to Lebanon and to monitor the suitability of the Lebanese urban cover, informal settlement data was extracted from IAMP and UNHCR (2016) and the 2013–2017 LU/LC maps (Faour and Abdallah, 2013, 2018), while urban classes were obtained from the 2013–2017 LU/LC maps (Faour and Abdallah, 2013, 2018). The selected datasets were then placed over Darwish et al. (2005) national land capability classification map. This step was performed for two reasons: (1) to determine the expansion rate of the Lebanese urban cover and (2) to identify the type of lands on which urban classes and informal settlements are concentrated.

In addition, since household practices differ between urban and informal settlements, an examination of contract types, waste disposal methods and means of water consumption in the informal settlements was performed. The three investigated parameters were also obtained from the IAMP and UNHCR (2016) dataset. These served to understand and anticipate potential conflicts (between refugees or between host populations and refugees) and to visualize the extra pressure on land resources.

4.1.1 Lebanese urban cover expansion

Table III presents the urban classes and their corresponding changes between 2013 and 2017. As can be seen, urban areas increased by 105 km^2 within four years. This rate is very high for a country as small as Lebanon and clearly reveals an active ongoing urbanization. The most considerable changes occurred in the low-density urban fabrics, medium density urban fabrics, dense urban fabrics, urban sprawls on field and permanent crops, and mineral extraction sites. The urban growth rate alone is a significant indicator; however, it is equally important to determine on which land capability classes these changes occur. As mentioned previously, areas of concern are prime lands (classes I and II), where the presence of urban cover on these categories clearly reflects the absence of urban planning based on land potential.

Accordingly, urban expansion on these classes fuels a cycle of increased land underuse leading to land loss, which decreases land capital, leading to irreversible modifications that trigger land degradation. Table II reveals that urban classes occupied an area of 1,102.30 km^2 in 2013. This area had a net increase of 105 km^2 in urban classes, accounting for 1,207.55 km^2 in 2017. Most of the expansion on prime lands occurred on class I (30.34 km^2 increase), in addition to an 18 km^2 increase above class II. The findings of this section imply that around 50 per cent of urban development in the last four years occurred over prime lands. These alarming numbers converge with Darwish's (2012) observations, where he reported that urban encroachment on arable lands in Lebanon has become chaotic. Furthermore, these findings solidify the lack of governance, land stewardship and absence of management plans reported by Verdeil et al. (2016). The rapid loss of arable lands only worsens land degradation in Lebanon and further threatens its food security (Zdruli, 2014).

At the governorate scale, the distribution of urban classes on prime lands in 2017 was as follows: Akkar 57.43 per cent, Baalbek–El Hermel 82.17 per cent, Bekaa 68.29 per cent, Beirut 100 per cent, Mount Lebanon 42.12 per cent, Nabatieh 50.46 per cent, North 23.24 per cent, and South 55.46 per cent. Mount Lebanon was found to be the most urbanized governorate in contrast to Akkar. Most urbanization on class I lands were in the Bekaa governorate, with more than two-thirds of its total urban cover overlaying the most optimal land class.

Urban classes	Urban classes (level 4)	Area13_I	Area17_I	Area13_II	Area17_II	Area13_III	Area17_III	Area13_IV	Area17_IV	Total Area 2013	Total Area 2017
Industrial,commercial andtransportunits	Airport	11.25	11.25	0.03	0.03	0.49	0.54	0.23	0.23	12.00	12.06
	Industrial or Commercial Areas	19.78	20.79	7.40	7.47	4.16	4.59	16.99	17.49	48.34	50.34
	Highway	5.28	5.27	2.78	2.82	0.61	0.61	3.13	3.12	11.79	11.82
	Port Areas	1.74	1.72	0.11	0.11	0.13	0.13	0.24	0.24	2.23	2.19
	Port Basin	0.73	0.60	0.21	0.05	0.03	0.03	0.10	0.11	1.06	0.79
	Railway Station	0.05	0.05	0.00	0.00	0.00	0.00	0.00	0.00	0.05	0.05
	Tourist Resort	0.80	0.86	0.96	0.95	0.34	0.27	4.53	4.62	6.64	6.70
Artificialareas	Archaeological Sites	0.66	0.66	0.07	0.07	0.00	0.00	0.21	0.17	0.94	0.90
	Cattle Raising	1.53	1.58	0.07	0.05	0.64	0.69	0.40	0.42	2.63	2.75
	Poultry Breeding	1.74	1.69	0.28	0.30	0.08	0.13	1.34	1.47	3.44	3.59
	Diverse Equipment	8.29	8.38	4.49	4.71	1.06	1.20	9.25	9.31	23.09	23.59
Artificial non-agricultural,vegetated areas	Green Sports Area	0.92	0.90	0.65	0.72	0.05	0.06	0.87	0.95	2.50	2.64
	Green Urban Areas	2.19	2.17	1.04	1.08	0.12	0.11	0.71	0.70	4.07	4.06
Discontinuousurban fabric	Low Density Informal Urban Fabric	1.51	2.38	0	0	0.73	0.87	0.72	0.92	2.95	4.17
	Medium Density Informal Urban Fabric	0.91	2.22	0.49	0.49	0.24	0.54	0.14	0.07	1.77	3.31
	Dense Informal Urban Fabric	3.40	4.72	1.70	1.70	0.05	0.46	0.14	0.20	5.30	7.09
Mine, dump and constructionsites	Landfill Sites	0.11	0.31	0	0.15	0.00	0.00	0.00	0	0.11	0.47
	Dump Sites	0.57	0.88	0.34	0.34	0.63	0.68	1.29	0.97	2.84	2.88
	Mineral Extraction Site	5.40	5.75	10.57	11.38	20.20	21.05	23.48	25.35	59.65	63.53
	Urban Extension/ Construction Sites	3.19	4.52	7.74	9.84	0.94	2.95	20.64	28.19	32.51	45.51
Continuousurbanfabric	Low Density Urban Fabric	39.05	43.22	50.28	54.55	21.47	23.12	125.92	138.46	236.72	259.36
	Medium Density Urban Fabric	83.67	96.04	131.57	139.50	36.34	39.35	207.61	225.02	459.20	499.91
	Dense Urban Fabric	72.55	75.87	24.67	25.65	8.88	9.45	31.94	33.96	138.03	144.93
Urbansprawlandurban vacant lands	Urban Sprawl on Clear Wooded Land	0.02	0.05	0	0.02	0.15	0.19	1.62	1.83	1.80	2.10
	Urban Sprawl on Dense Wooded Land	0	0	0.71	1.00	0.14	0.17	3.18	4.01	4.03	5.19
	Urban Sprawl on Field Crops	6.97	9.01	2.12	2.63	1.59	2.03	4.58	5.76	15.26	19.42
	Urban Sprawl on Permanent Crops	3.60	4.65	3.39	3.88	1.82	2.51	6.08	6.85	14.89	17.89
	Urban Sprawl on Protected Agriculture	0.04	0.03	0.04	0.06	0.00	0.00	3.27	4.45	3.35	4.54
	Urban Sprawl on Shrubland	0.98	1.61	1.69	1.82	1.65	1.46	0.09	0.09	4.41	4.98
	Urban Vacant Land	0.57	0.66	0.13	0.13	0.00	0.00	0.00	0.00	0.70	0.80
Total		**277.51**	**307.85**	**253.53**	**271.53**	**102.55**	**113.20**	**468.70**	**514.96**	**1,102.30**	**1,207.55**

Table III: Evolution of the urban cover in Lebanon between 2013 and 2017 (in km^2)

At such a pace, the lands needed for supporting human livelihood and agriculture will be much greater than what is available. With already limited resources and funds for land restoration, urban expansion will result in irreversible land losses if left unregulated. Proactive planning and policies are thus needed to halt the process, since avoiding land degradation is less environmentally and economically costly than treating it.

4.1.2 Informal settlements: expansion and practices

According to the IAMP and UNHCR (2016), 3,758 Syrian informal settlements are scattered throughout Lebanon: 52 in Nabatieh, 87 in Mount Lebanon, 119 in South Lebanon, 327 in North Lebanon, 706 in Akkar, 1,128 in Baalbek–El Hermel, and 1,339 in Bekaa. The above-mentioned distribution can be attributed to several reasons: (1) most Syrian refugees engage in agriculture-related occupations (ILO, 2014); (2) the last three governorates provide the most affordable settings for the incoming refugees; and (3) the three governorates are the closest to the formal and informal Lebanese-Syrian borders. However, Akkar, Bekaa and Baalbek–El Hermel are the country's poorest and marginalized regions (ILO, 2014). Subsequently, the presence of refugees in these areas worsens their already difficult situation (FAO, MoA, and REACH, 2014).

As can be seen in Figure II, settlements in these three governorates are aggregated on the country's most optimal lands (class I). The intersection of the informal settlement layer and the land capability classification map solidified Nassar and Elsayed's (2018) observation regarding the expansion of urban settlements mostly in agricultural lands. In the case of Lebanon, most of these informal settlements also occupy the country's

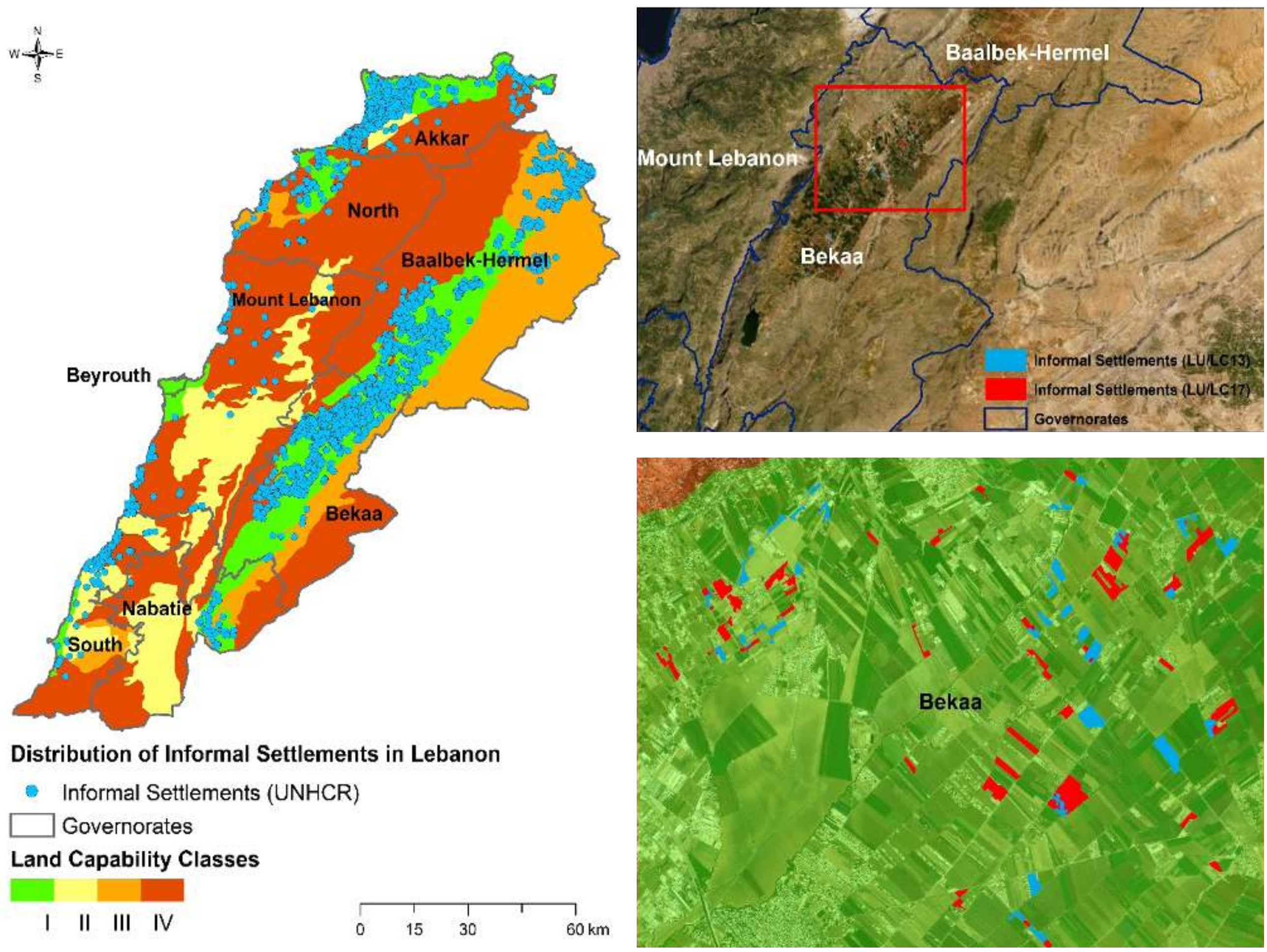


Figure II: Distribution of informal settlements in Lebanon with respect to land capability classes (2013–2017).

prime lands (classes I and II). These findings converge with Aguilar and Santos' (2011) statement regarding the expansion of informal settlements over lands with important capability and considerable ecological potential. Thereby, the occupation of informal settlements on prime lands per governorate is as follows: 46/52 (88.46 per cent) in Nabatieh, 17/87 (19.5 per cent) in Mount Lebanon, 94/119 (79 per cent) in the South, 143/327 (43.7 per cent) in the North, 659/706 (93.3 per cent) in Akkar, 652/1,128 (57.8 per cent) in Baalbek–El Hermel, and 1,199/1,339 (89.54 per cent) in Bekaa.

This emplacement puts additional stress on the country's already burdened arable lands and exacerbates further pressure on land resources. In turn, increased pressure leads to land overuse, which causes land degradation (Karlen and Rice, 2015). Accordingly, the FAO, MoA, and REACH (2014) reported increased evidence of resource depletion, land degradation and habitat destruction in governorates with highest shares of informal populations. These concerns equally influence both host and refugee communities. It is particularly important to consider the concentration of settlements in Bekaa, since this governorate is considered as the country's food bank. Nearly 42 per cent of Lebanon's cultivated lands are located in this governorate (Habib, 2019). Overpopulation in Bekaa severely impacted food security in the country (Government of Lebanon and United Nations, 2019) and exhausted an already burdened governorate (Habib, 2019).

Additional monitoring was performed by extracting the count and areas of informal settlements in each governorate from the 2013 and 2017 LU/LC maps (Faour and Abdallah, 2013, 2018). The findings from Table IV converge with the IAMP and UNHCR (2016) data. While IAMP and UNHCR (2016) are punctual data, informal settlements from the LU/LC maps are obtained as polygons. As can be seen, Akkar, Bekaa and Baalbek–El Hermel are the most informally dense governorates with significant increases in the four years monitored. While in Akkar and Bekaa considerable increase of medium density and dense informal settlements are observed, sharp increases of all informal settlement categories in Baalbek–El Hermel are noted.

Governorates	Informal settle-*ments	Count 2013	Count 2017	Area 2013 (km²)	Area 2017 (km²)
Akkar	LDIS	7	7	0.23	0.39
	MDIS	**0**	**7**	0	0.16
	DIF	**1**	**8**	0.056	0.24
	Total	**8**	**22**	**0.286**	**0.79**
Baalbek–El Hermel	LDIS	**44**	**66**	1.19	2.12
	MDIS	**8**	**44**	0.28	1.28
	DIF	**5**	**16**	0.06	0.51
	Total	**57**	**126**	**1.53**	**3.91**
Bekaa	LDIS	51	50	1.14	1.05
	MDIS	**18**	**31**	0.76	1.38
	DIF	**12**	**37**	0.37	1.52
	Total	**81**	**118**	**2.27**	**3.95**
Beirut	LDIS	0	0	0	0
	MDIS	0	0	0	0
	DIF	2	2	0.086	0.56
	Total	**2**	**2**	**0.086**	**0.56**
Mount Lebanon	LDIS	0	2	0	0.04
	MDIS	3	1	0.35	0.21
	DIF	5	5	1.43	1.5
	Total	**8**	**8**	**1.78**	**1.75**
Nabatieh	LDIS	**3**	**11**	0.063	0.22
	MDIS	1	1	0.04	0.045
	DIF	0	0	0	0
	Total	**4**	**12**	**0.103**	**0.265**
North	LDIS	2	1	0.22	0.23
	MDIS	1	1	0.037	0.037
	DIF	2	2	0.57	0.57
	Total	**5**	**4**	**0.827**	**0.837**
South	LDIS	2	2	0.1	0.1
	MDIS	4	4	0.3	0.3
	DIF	6	6	2.7	2.7
	Total	**12**	**12**	**3.1**	**3.1**
National total	**Total number**	**177 :2013 304 :2017**	**Total Area**	**km² 9.98 :2013 km² 15.162 :2017**	

*Low-density informal settlements (LDIS), Medium density informal settlements (MDIS), Dense informal settlements (DIF)

Table IV: Number of informal settlements according to governorate (2013–2017)

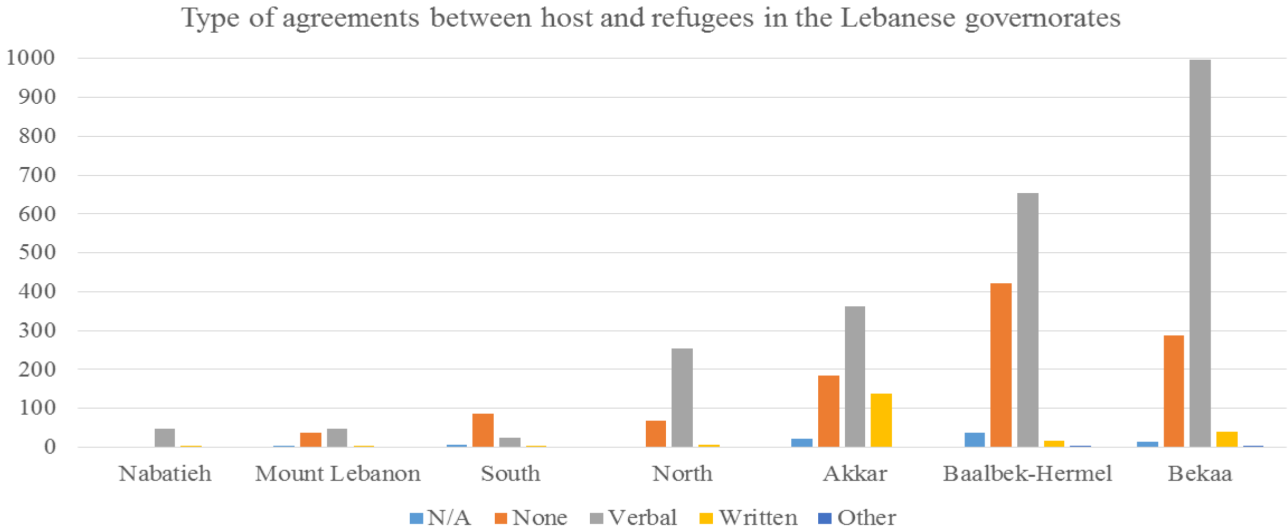


Figure III: Type of host-community agreement for informal settlements, according to governorate.

The presence of settlements throughout the country further drives several changes to the surrounding environment due to settlements related practices. For that purpose, the contract type between the host and refugees, waste disposal means and water consumption methods were also considered. Contract types prospect potential host–refugee conflicts and hence refugee return possibilities, waste disposal means provide insights on pollution and additional land degradation, while water consumption methods help infer resource stress or competition. According to the IAMP and UNHCR (2016) datasets, the following results were found:

Contract or agreement types: Five categories of agreements are prevalent: N/A, none, verbal, written and other. In six out of seven governorates (excluding Beirut where no informal settlements are present), the verbal type of agreement between hosts and refugees is the most common (see Figure III). In the South governorate, the no agreement (none) type is the most prevalent. In terms of land ownership, settlements are located on public lands but most are on private properties rented through NGOs.

At a finer administrative level (i.e. caza or district scale), the following districts were found to house the highest number of settlements within their corresponding governorates: Marjaayoun in Nabatieh, Chouf in Mount Lebanon, Saida in the South, Minnie-Daniye in the North, Akkar in Akkar, Baalbek in Baalbek–El Hermel, and Zahle in Bekaa. The verbal type of agreement is widespread since it is considered most flexible, giving both hosts and refugees communities a certain degree of freedom (UN-Habitat and UNHCR, 2018). While written agreements oblige signing parties to pay considerable amounts of money and require mutual commitments, verbal agreements allow refugees to move out at will, and allow land owners to avoid paying compensations in case of eviction (UN-Habitat and UNHCR, 2018). The no agreement category corresponds to the case where refugees work for their landlords as a means to pay rent (UNICEF, UNHCR and WFP, 2017). Despite the advantages of verbal agreements, several incidents have been reported between hosts and refugee communities (SFCG, 2014). These conflicts are mainly due to sudden changes in rent prices (UNICEF, UNHCR and WFP, 2017, 2019), to forced evictions (Habib, 2019), and in some cases to the unwillingness of refugees to move out or to return to their country (Hochberg, 2019). While these conflicts are local and short in time, these have the potential to fuel tensions and escalate violence between the neighbouring communities. Such disturbances have been noted and "domestic" conflicts have been documented (Habib, 2019). The main concerns in this case are changes of landscape features, over pressuring of resources, changes in socioeconomic conditions, and conflict-driven LU/LC transitions (Mubareka and Ehrlich, 2010).

Waste disposal methods and water consumption: Waste generation, storage and disposal are established and acknowledged drivers of land degradation (Yazdani et al., 2015). As mentioned previously, Lebanon suffers from an ongoing crisis in its waste disposal system, and additional generation from informal settlements only exasperates the problem. The IAMP and UNHCR (2016) dataset revealed five types of waste disposal in informal settlements: N/A, burning, dumping outside the camp, municipal collection and burial. Only one of these methods (municipal collection) is considered suitable, while the rest are seen as harmful. In most governorates, wastes are removed by municipal collection; however, burning and dumping outside the camp are the second and third most common practices. Burning is most common in Baalbek–El Hermel, while dumping outside camps is mostly practiced in Bekaa. Waste burial is mostly practiced in Akkar, in addition to non-determined dumping methods. Waste burning releases air pollution; waste burial causes leachate pollution, while open-dumping generates both air pollution and leachate spread (MoE, UNDP, and ELARD, 2017). Considering that most of these practices occur over prime lands (see Figure II), they pose environmental, land degradation and further stress on the country's prime lands.

Water consumption: Jaafar, Ahmad, Holtmeier, and King-Okumu (2019) conducted a recent review of refugee impact on water balance and water stress in Lebanon. Their findings revealed that water stress increased by 6 per cent, while domestic water use increased by 20 per cent. Hussein, Natta, Yehya, and Hamadna (2020) found that the refugee influx, combined with climate change manifestations, has greatly aggravated water-related problems. According to Jaafar, Ahmad, Holtmeier, and King-Okumu (2019), the most affected areas are Bekaa and the coastal areas of the North and South governorates. IAMP and UNHCR (2016) identified eight water consumption patterns in informal settlements: N/A, boreholes, rivers, springs, water networks, water trucking, wells and others. The most frequently used are water trucking, boreholes, wells and water networks. In the most crowded governorates (Akkar, Bekaa and Baalbek–El Hermel), the most common means are wells, water trucking and boreholes, respectively. In the semi-arid Bekaa and Baalbek–El Hermel governorates, water scarcity was already a problem even before 2011, and higher water demand creates resource competition.

In conclusion, indicator 4.1.2 findings reveal contested access to fertile lands and water resources, whereby the resulting competition and overexploitation increase the vulnerability of host communities (Muchena, 2008) and place additional stress on already vulnerable refugee populations. With scarce resources, host communities will naturally feel threatened by the population influx. This state of insecurity brought about by increasing demands and subsequent resource competition fuels tension that trigger conflicts (Bruce and Holt, 2011) and aggravate land degradation. Several concerns are expressed in this case where fears of using this humanitarian crisis as a geopolitical leverage point for both host and home countries are prevalent.

4.2 Indicator 2: population shifts with additional non-Lebanese residents and demographic changes

The last comprehensive population census of Lebanon took place in 1932, during the French mandate, and has never been updated due to the delicate sectarian and political situation. However, the Lebanese CAS performed several missions to gather population statistics. In 2007, 3,759,136 people (excluding Palestinian refugees) lived in Lebanon (CAS, 2007). The most recent CAS survey (CAS, ILO and EU 2020) reported that the total population of Lebanon in 2019 was 4,842,000 inhabitants (3,862,000 Lebanese citizens and 978,000 non-Lebanese residents). As of 2015, UNHCR had already registered 1,500,000 Syrian refugees; however, based on the demand of the Lebanese government, it stopped registering refugees in May 2015 (UNHCR, 2020). Consequently, the number of refugees in Lebanon is unknown and subjected to fluctuations. Further uncertainties in the Lebanese population statistics can also be attributed to the presence of non-Syrian refugees (Iraqis and Palestinians). These uncertainties are strikingly apparent when comparing the CAS numbers with World Bank data: 4,842,000 versus 6,855,173 residents, respectively. Regardless of the actual number, no other country in the world has welcomed so many refugees compared to its size (Kelley, 2017). The presence of so many refugees has raised many questions and crated considerable internal tensions that escalated into armed conflicts on several occasions, driven by several key factors:

i. Job competitions, particularly in low-income governorates such as Bekaa, where the foreign workforce significantly surpassed the Lebanese labour force (UNICEF, UNHCR and WFP, 2017);

ii. Resource competition (Bruce and Holt, 2011);

iii. Underlying grudges due to Syria's role in successive Lebanese war episodes (Habib, 2019);

iv. Geopolitical and social differences.
Therefore, the topic of refugees and its different perceptions are politically and ethnically sensitive issues in Lebanon. While the only available numbers are those issued from the CAS, Figure IV reveals

the distribution of the Lebanese and non-Lebanese populations in the country. Following CAS, ILO, and EU (2020) statistics, the governorates with highest populations in descending order are Mount Lebanon, the North, El Nabatieh, the South, Akkar, Baalbek–El Hermel, Beirut and Bekaa. Subsequently, increased pressure on land resources will be proportional to the population density of each governorate. According to World Bank (2019b), Lebanon had a population density of 669 people/km^2 in 2018, ranking as 19th among the 20 most densely populated countries of the world. These high numbers accelerate rates of land degradation at paces much faster than anticipated (Ferreira et al., 2018). The large refugee communities add a new pressure layer to the already crowded governorates. Naturally, the effect of overpopulation differs from one context to another depending on the socioeconomic factors. Zaman et al. (2011) found that high population density in low-income contexts exacerbates further land and environmental degradation. To understand this situation in Lebanon, income data from the CAS, ILO, and EU (2020) statistics were also analysed.

As can be seen, the most common income categories for Lebanese households are 800,000–1,000,000, 1,000,000–1,200,000, 1,200,000–1,600,000, and 1,600,000–2,400,000. According to Figure V, in

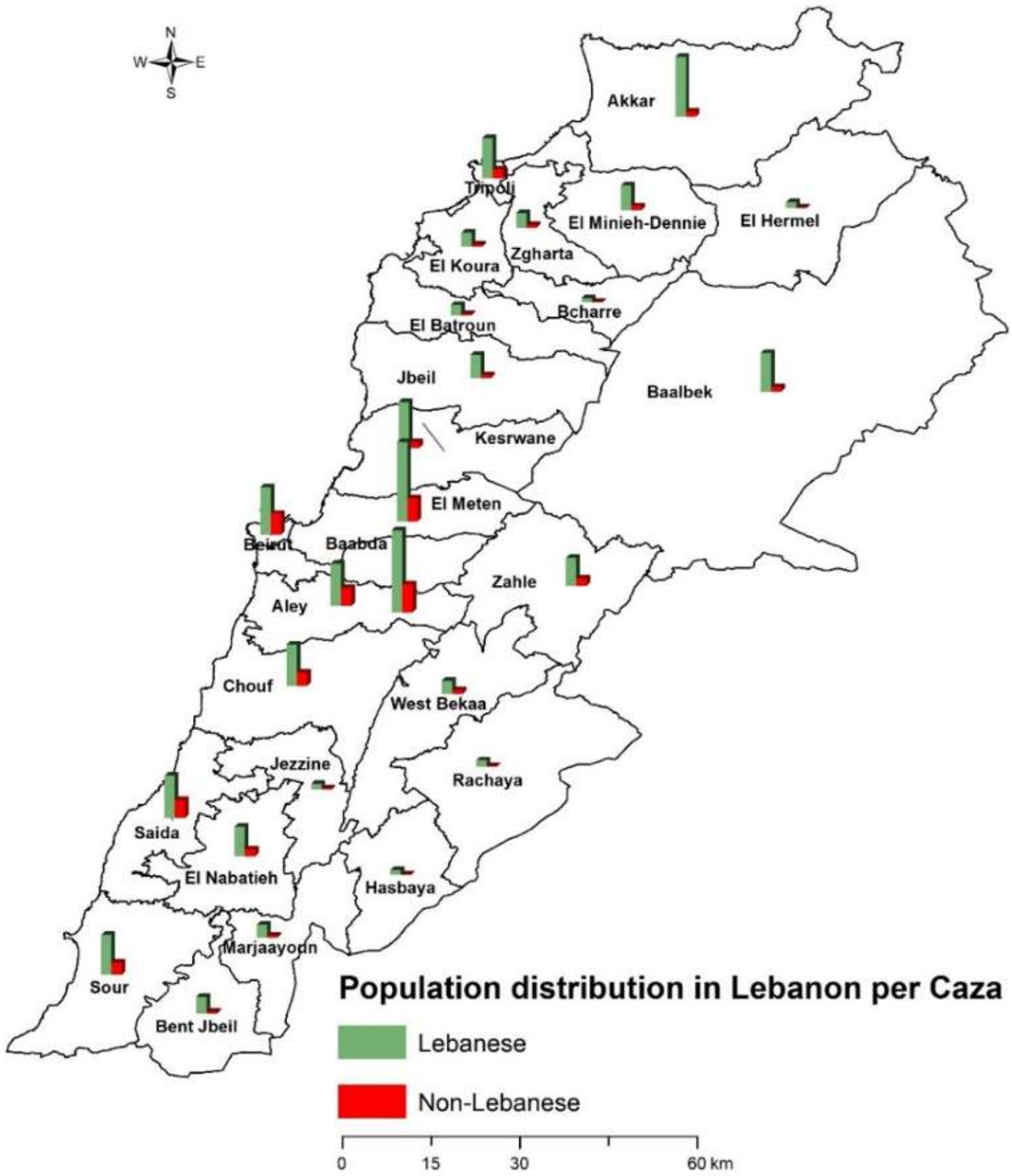


Figure IV: Population distribution of Lebanese and non-Lebanese residents (2018–2019). Source: CAS, ILO and EU (2020).

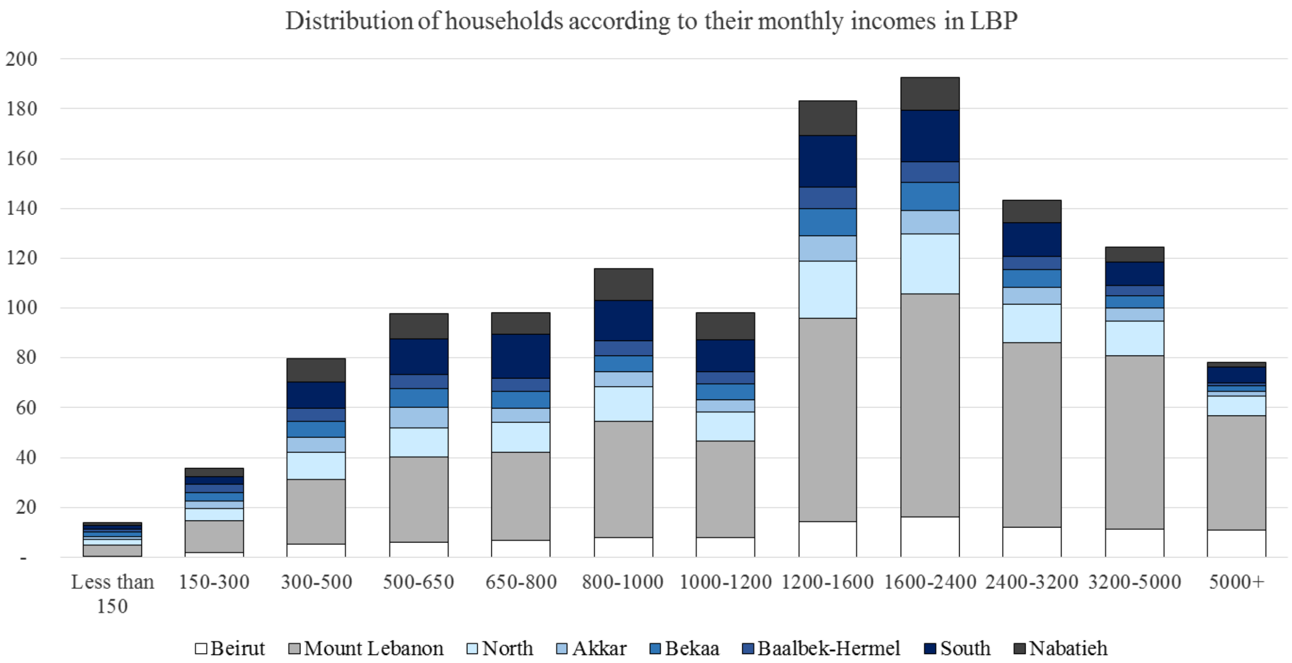


Figure V: Distribution of monthly household income per governorate (in LBP 1,000s) (2018–2019).

Akkar, Bekaa, and Baalbek–El Hermel, the number of households falling within the income categories of interest is considerably less than in the other governorates. With reference to indicator 4.1.2, where Akkar, Bekaa and Baalbek–El Hermel were found to house the highest number of refugees, the population of these rural governorates finds itself exposed to increased vulnerability (Iosifides and Korres, 2002b). The labour market in these governorates is severely burdened by the presence of refugees (Ajluni and Kawar, 2015; Kumar et al., 2018), since Syrians are willing to work more hours for lower pay and without social security contributions (FAO, MoA, and REACH 2014).

At the national scale, overpopulation is bound to decrease terrestrial eco-services and promote unsustainable land use and management (Gerber et al., 2014), which in turn leads to land degradation (Al-Sayah et al., 2019a). However, since land degradation is heterogeneous, even within the same landscape (Nyssen et al., 2009), asymmetrical impacts throughout the country are expected. These disproportional effects are due to the different intrinsic and socioeconomic characteristics of each context. Accordingly, land degradation is considered an amplifier of socioeconomic inequalities.

4.3 Indicator 3: abandoned agricultural lands with respect to land capability classes

Agrarian abandonment compounds the devaluation of land potential and has far-reaching socioeconomic and environmental repercussions (Khanal and Watanabe, 2006). Abandoned agricultural lands, especially those with considerable productive capacity are central for enhancing food security and a much-needed resource for the fight against land degradation. For that purpose, abandoned agricultural lands were extracted from the 2013 and 2017 LU/LC maps (Faour and Abdallah, 2013, 2018) to investigate their evolution. Figure VI reveals the distribution of these lands with respect to the different land capability classes. The intersection of both layers was performed, since agrarian abandonment over lands of low productive capacity is not considered as mismanagement and cannot be directly regarded as a tangible form of land degradation. On the other hand, agrarian abandonment over arable or prime lands (I and II) is a form of land underuse that ultimately leads to land degradation.

At the national scale, abandoned agricultural lands covered 113 km^2 out of the 2,898 km^2 agricultural spaces in 2013, while in 2017, they covered 110 km^2

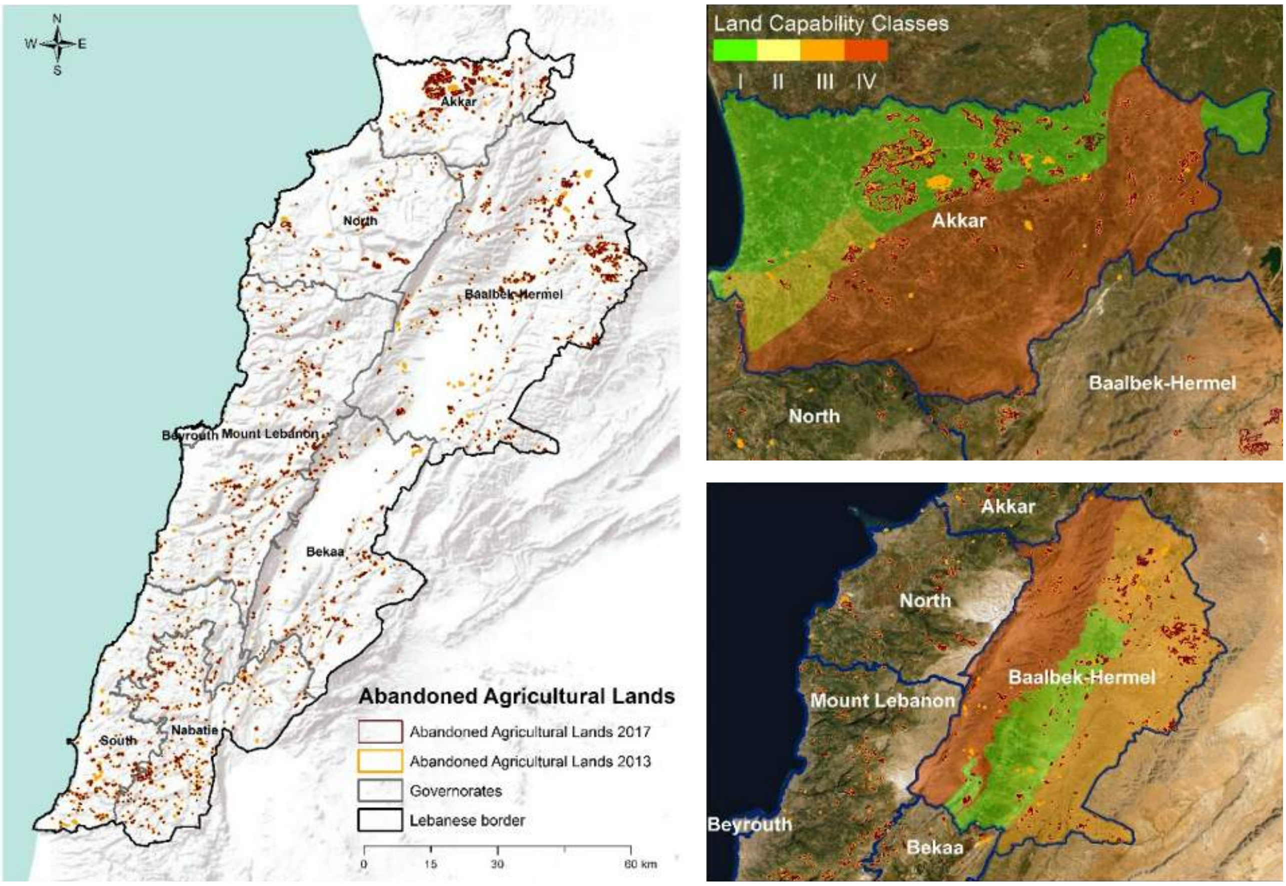


Figure VI: Distribution of abandoned agricultural lands in Lebanon with respect to land capability classes (2013–2017).

out of 2,854 km^2. A considerable decrease of planted areas can be deduced. In addition to these numbers, food imports in the country are still very high, with more than 80 per cent of food stocks being imported yearly (ESCWA, 2016). According to estimates reported by Abdallah et al. (2018), the contribution of agriculture dropped from 23 per cent to only 4 per cent of national GDP. As of 2017, abandoned agricultural lands were distributed in the country as follows: 30 km^2 in Baalbek–El Hermel, 27 km^2 in Akkar, 14.5 km^2 in Nabatieh, 13.7 km^2 in Mount Lebanon, 9 km^2 in the South, 8.7 km^2 in Bekaa and 8 km^2 in the North. With respect to the 2013 baseline, minor changes are observed in each governorate except for Bekaa. Despite the agricultural importance of this governorate and its role in supporting Lebanon's food security, abandoned agricultural lands increased in Bekaa from 7.7 km^2 in 2013 to 8.7 km^2 in 2017.

With the increase of population in the country and the decrease of potent available arable lands, restoring abandoned agricultural spaces over lands of considerable capacity is a must. As mentioned previously, this focus must be shifted towards the abandoned spaces on the prime lands (I and II). At the national scale, 42 per cent of the country's abandoned agricultural lands coincided on land capability classes I and II. Based on these numbers, the absence of land potential–based agricultural management can be deduced. In order to quantify target areas and halt the ongoing loss of land potential in each governorate, the areas and extent of abandoned agricultural lands with respect to land capability classes were determined.

According to Table V, Akkar is the governorate with the most abandoned agricultural lands over prime lands (81.62 per cent), followed by Mount Lebanon, El Nabatieh, the South, and Bekaa. From the results, considerable areas in each governorate can be targeted to reduce land underuse and thus avoid land degradation. Accordingly, 21.98 km^2 of abandoned agricultural lands in Akkar, 5.21 km^2 in Baalbek–El Hermel, 2.51 km^2 in Bekaa, 8.09 km^2 in Mount Lebanon, 5.66 km^2 in El Nabatieh, and 2.85 km^2 in the South should be shifted towards agricultural use. This intervention would reduce land loss potential leading to land degradation, while enhancing food security. It is equally important to target abandoned agricultural lands covering land classes III and IV, as agrarian abandonment leaves the topsoil layers exposed to various erosive factors. Due to the absence of vegetation cover, the surface protective barrier against wind and water is lost (Durán Zuazo et al., 2008)where rainfall is scarce and irregular but often of high intensity, wild shrubs protect the soil against erosivity of raindrops. Moreover, some of these plants are the economic income for local farmers. Particularly in SE Spain, soil erosion is a core factor in environmental degradation attributed primarily to the cultivation practices and human pressure on the land. Over a four-year period, soil erosion and runoff were monitored in erosion plots on a mountainside, comparing four harvest intensities of four aromatic shrubs (Lavandula lanata L., Santolina rosmarinifolia L. Origanum bastetanum, and Salvia lavandulifolia V., while soil stability is reduced by the absence of roots (De Baets et al., 2007). According to FAO (2019), soil erosion is the most amplified biophysical form of land degradation. Since agrarian abandonment intensifies soil erosion and sediment transport yields (García-Ruiz and Lana-Renault, 2011)particularly in mountain areas and semiarid environments. In such places, farmland abandonment represents a significant land use change from cropping to a complex of plant successions. The present study assesses the hydromorphological effects of land abandonment in Europe, and the consequences thereof with respect to water resource availability and soil erosion. The evolution of abandoned fields depends on (i, abandoned agricultural lands over land classes III and IV should be revegetated to avoid further land degradation.

Governorate	AAL-I* Area ((km²	AAL-II Area ((km²	AAL-III Area ((km²	AAL-IV Area ((km²	Total Area ((km²	AAL-I 2013 (%)	AAL-II (%) 2013	AAL-III (%) 2013	AAL-IV (%) 2013
Akkar	21.34	1.02	0	4.88	27.24	78.34	3.74	0	17.91
Baalbek–El Hermel	5.36	0	20.62	4.83	30.93	17.33	0	66.67	15.62
Beirut	0	0	0	0	**0**	0	0	0	0
Bekaa	1.72	0.73	1.9	3.4	7.75	22.19	3.29	57.76	5.89
Mount Lebanon	0	8.03	0	5.36	13.39	0	59.97	0	40.03
El Nabatieh	1.45	4.57	0.65	8.03	14.7	9.86	31.09	4.42	54.63
North	0.44	0.13	2.66	6	9.23	4.77	1.41	28.82	65.01
South	0.14	3.05	1.3	5.77	10.26	1.36	29.73	12.67	56.24
National total of AAL	30.46	17.53	27.12	38.23	**113.34**	26.88	15.46	23.92	33.73
Governorate	**AAL-I Area ((km²**	**AAL-II Area ((km²**	**AAL-III Area ((km²**	**AAL-IV Area ((km²**	**Total Area ((km²**	**AAL-I 2017 (%)**	**AAL-II 2017 (%)**	**AAL-III 2017 (%)**	**AAL-IV 2017 (%)**
Akkar	21.1	0.88	0	4.95	**26.93**	78.35	3.27	0	18.38
Baalbek–El Hermel	5.21	0	20.3	4.26	**29.86**	17.45	0	67.98	14.27
Beirut	0	0	0	0	**0**	0	0	0	0
Bekaa	1.63	0.88	2.28	3.89	**8.68**	18.78	10.14	26.27	44.82
Mount Lebanon	0	8.09	0	5.59	**13.68**	0	59.14	0	40.86
El Nabatieh	1.34	4.32	0.56	8.28	**14.5**	9.24	29.79	3.86	57.10
North	0.32	0.15	1.7	5.9	**8.07**	3.97	1.86	21.07	73.11
South	0.06	2.79	1.09	5.13	**9.07**	0.66	30.76	12.02	56.56
National total of AAL	29.69	17.01	25.91	37.99	**110.6**	26.84	15.37	23.42	34.34

*abandoned agricultural lands

Table V: Distribution and extent of abandoned agricultural lands, according to land capability classes (2013 vs 2017)

At this stage, a comprehensive plan for restoring abandoned agricultural lands is proposed. Those found on land classes I and II should be rehabilitated to halt the loss of land capital. Those overlying land classes III and IV should be revegetated, to preserve land resources by avoiding soil erosion–induced land degradation. Attending to abandoned agricultural lands is also important for preventing wildfires. According to Stougiannidou, Zafeiriou, and Raftoyannis (2019), abandoned agricultural lands accumulate biomass that can fuel wildfires. Therefore, these zones must be cleared, reforested/vegetated or shifted towards agricultural use where suitable to avoid additional land degradation. Such approaches are listed as targets in MoA's 2020 strategy.

4.4 Indicator 4: quarry cover expansion with respect to land capability classes

In their review of quarry expansion in Lebanon, Darwish et al. (2008) reported that quarry cover increased from 2,875 ha to 5,283 ha between the late 1990s and 2005, with around 17 per cent of quarries emerging on arable lands. Darwish et al. (2011) then reported a tripling of quarry area over arable lands, a doubling over pasture lands, and a one-third increase over forests, resulting in a total loss of 1,550 ha of productive lands and 2,192 ha of prime lands. To monitor quarry cover expansion for this study, mineral extraction sites (quarries) were extracted utilizing LU/LC maps. At the national scale, quarry cover shifted from 52.83 km^2 (5,283 ha) in 2005 to 59.62 km^2 in 2013, and to 63.51 km^2 in 2017. While according to Darwish et al. (2008), 17 per cent of the quarry cover was overlaying prime lands, around 27 per cent of the quarried land area occupied prime lands in 2017. At the governorate scale, quarried land area was distributed as follows: 19.64 km^2 in Baalbek–El Hermel, 17.44 km^2 in Mount Lebanon, 7.51 km^2 in Bekaa, 7.06 km^2 in the North, 5.52 km^2 in Nabatieh, 5.48 km^2 in the South, and 0.88 km^2 in Akkar. Logically, quarry expansion should not be halted but rather shifted towards lands of low productive capacity. While this is the case in most governorates, Bekaa, Nabatieh and the South were exceptions. Accordingly, 54.7 per cent of quarry cover in Bekaa is over prime lands (50.47 per cent on class I, 4.26 per cent on class II); 57.25 per cent in Nabatieh (23.37 per cent on class I, 33.88 per cent on class II), while in the South 58.21 per cent was concentrated on class II lands. In recent years (2018 and 2019), the same distribution persisted, however, with slight differences showing minor increases or decreases in some cases.

With increased quarrying activity, particularly over prime lands, considerable land disturbance is expected. This feedback loop further drives land degradation and exacerbates existing losses. While quarrying activity is necessary for urban expansion and housing the increasing population, governmental oversight needs to improve. Enforced regulations should be applied before issuing quarrying permits, and plans for land reclamation/restoration within the quarry's surroundings should be set. Quarries and mineral extraction sites located on land classes III and IV are considered to be suitably distributed, since a trade-off between economic development and the preservation of land capital resource is conserved. However, for sustainable design of mineral extraction sites, afforestation is recommended within the sites' surroundings (Al-Sayah et al., 2019a).

4.5 Indicator 5: conflicts and exceptional events

According to Van Schaik and Dinnissen (2014), the relationship between land degradation and conflicts has not been thoroughly examined. Prior to this report no national scale study investigating the conflict–land degradation nexus has been performed. Despite its small size, the history and current situation of Lebanon have long been associated with conflicts that continue to destabilize the fragile country. The PRIO and ACLED databases were used to study Lebanon's conflicts and build a national conflict profile (see Figure VII).

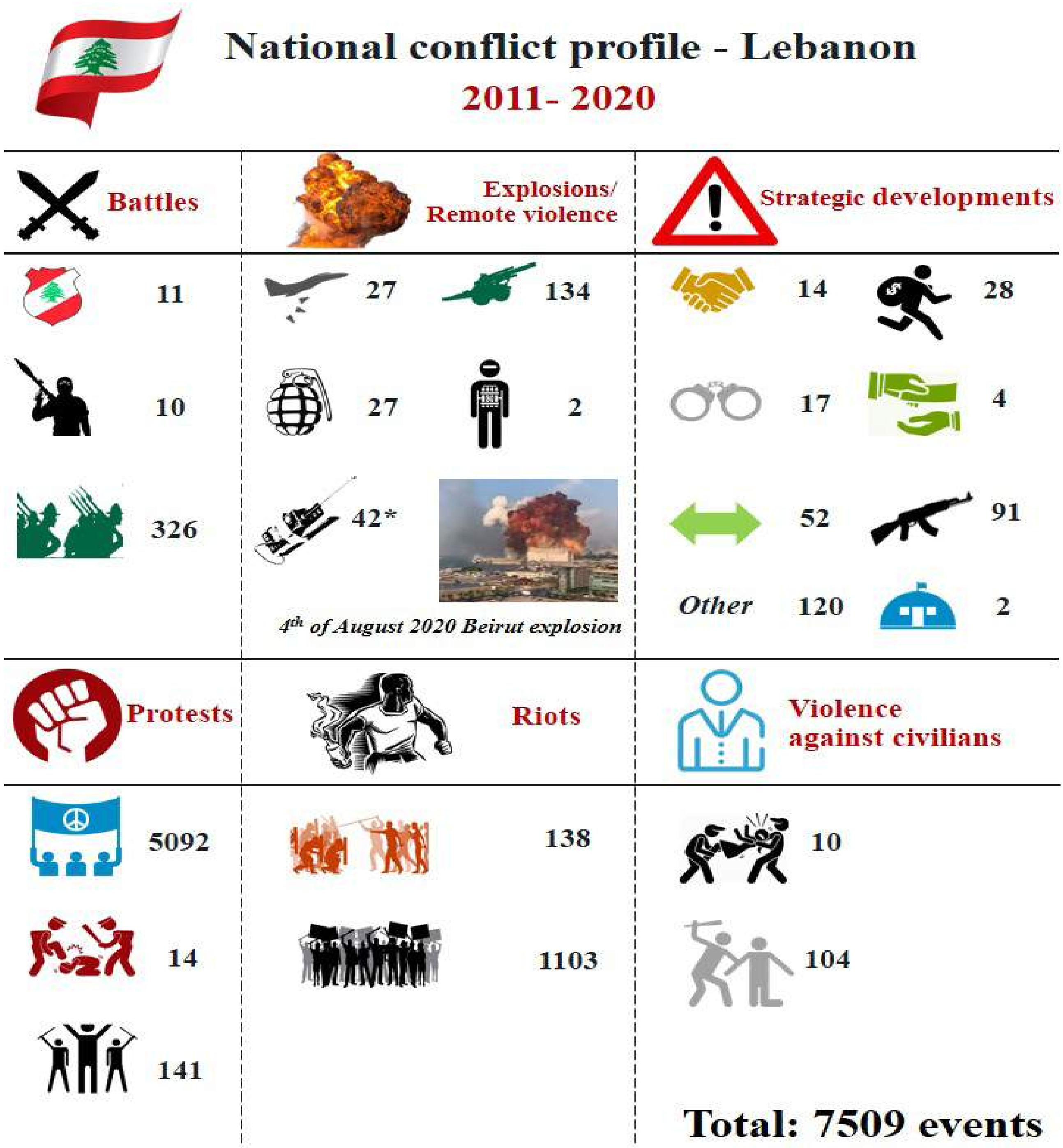


Figure VII: National conflict profile of Lebanon (2011–2020). Source: ACLED database.

Protests and riots are the most frequent, largely due to the ongoing 2019 revolution. A deeper dive revealed several other findings: the 2011–2015 period mostly featured protests and battles (89), largely linked to the Arab spring period. Most battles were local and concentrated in the North (43) and Baalbek–El Hermel (36), while one was transboundary conflict in the South. The 2016–2020 interval is much more eventful, and it is believed to have changed the current situation of Lebanon and is expected to cause far-reaching implications in the near future. Within this period 5,922 (78.86 per cent) out of the 7,509 events were recorded.

Year	Battles	Explosions/ Remote violence	Protests	Riots	Strategic developments	Violence against civilians	Total	Sum total
2016	88	112	121	17	28	20	386	**5,922**
2017	88	56	109	20	57	20	350	
2018	33	10	100	33	31	8	215	
2019	27	17	**1,991**	**358**	**84**	20	2,497	
2020	38	19	**1,856**	**474**	58	29	2,474	

Table VI: Recent conflicts and events in Lebanon (2016–2020)

As seen in Table VI, protests were the most prevalent events. The 2015–2016 protests erupted as a reaction to the collapse of the Lebanese waste disposal system that left tons of garbage on the streets. In 2017–2018, protests continued however with different purposes and political messages. The situation culminated in 2019 as the ongoing October revolution erupted. When considering violent events, the years 2016 and 2017 witnessed the highest number of battles and explosions. During this period, the Lebanese army clashed with terrorist groups such as ISIS and its associated militias. These conflicts brought about considerable changes by modifying or creating LU/LC patterns, such as the expansion of informal settlements in Baalbek–El Hermel and Bekaa. The decrease in incidents from 2016 to 2018 reflects a period of relative stability, which was shattered by several underlying factors and political shocks, setting the stage for the October 2019 revolution. In August 2020, the Beirut Port explosion of 2,700 tonnes of ammonium nitrate – labelled as one of the strongest non-nuclear explosions ever recorded (Clifton, 2020), radiating shockwaves as far as Cyprus – levelled catastrophic damage (see Figure VIII) up to 20 km from the blast's epicentre (OCHA, 2020)**.**

Figure VIII: Beirut Port before and after the 4 August 2020 explosion.

For a more detailed analysis, Figure IX presents the distribution of conflicts at the governorate and national scales between 2016 and 2020.

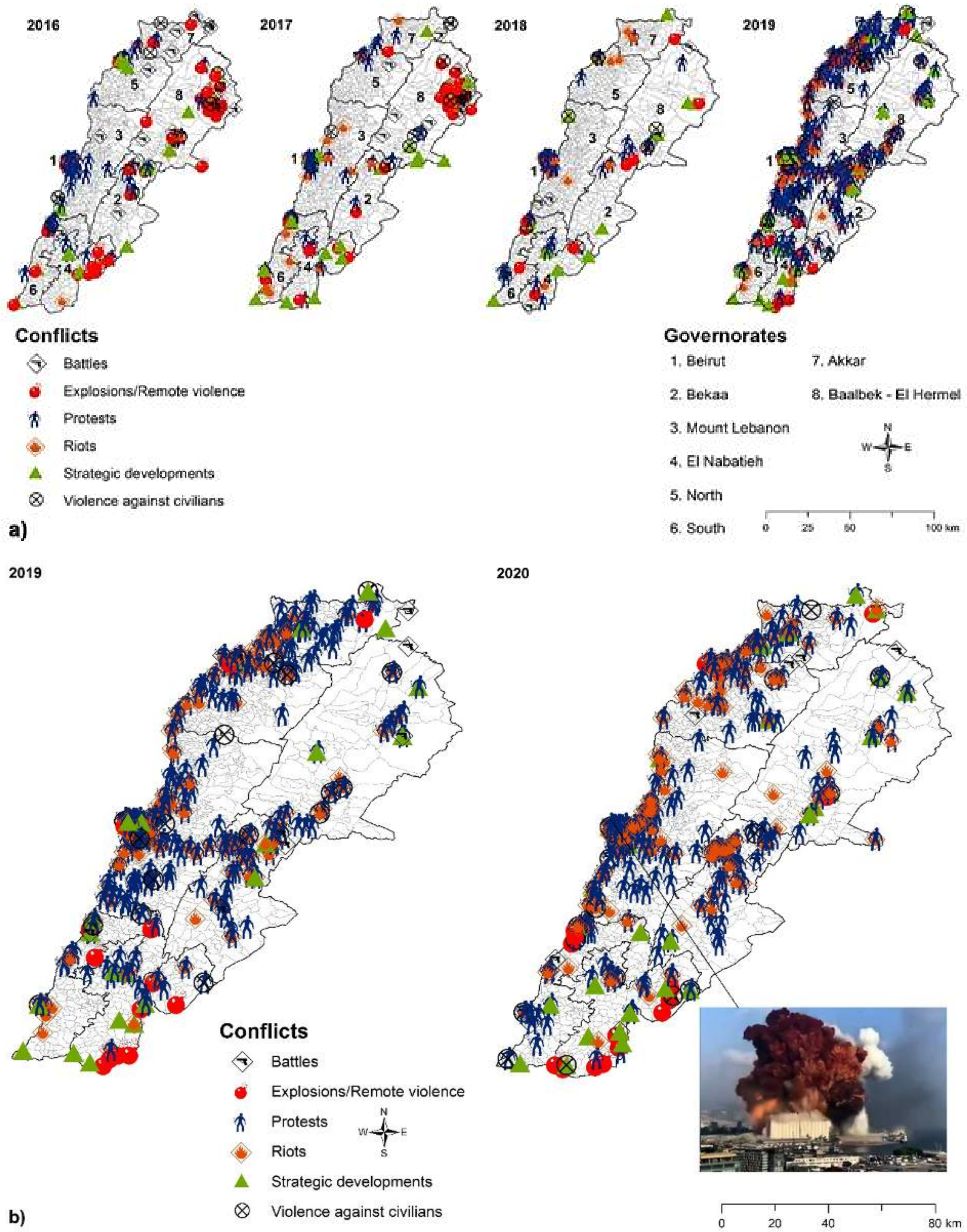


Figure IX: a) Conflict maps for 2016–2019; b) Conflict maps for 2019–2020 (October revolution and Beirut Port explosion).

The most notable features in 2016 and 2017 are the explosions/remote violence acts in the Nabatieh (Israeli-Lebanese war fallout) and Baalbek–El Hermel governorates (due to ISIS bombings). In 2017, explosions and strategic developments increased significantly in Baalbek–El Hermel leading to the clashes between the Lebanese army and terrorist groups (Operation Fajr Al-Jaroud, dawn of the mountains). It is important to mention that mines dating back to the civil war are still scattered through the country. The Lebanese army knows their locations, but clearing these areas requires a lot of effort and resources. While 2018 was relatively stable, 2019 marked a very unstable period of Lebanon's history, with protests throughout the entire country. Looking at the level of governorate, the 2011–2020 period was distinguished by the following: Beirut (1,199 events), Mount Lebanon (1,017 events), North Lebanon (993 events), South Lebanon (701 events), Bekaa (632 events), Baalbek–El Hermel (566 events), Akkar (462 events) and Nabatieh (343 events). In addition to these rankings, each governorate is characterized by specific events (other than protests and riots). Accordingly, strategic developments are the most common type in Beirut, while battles are the most common event in the North (22) and Mount Lebanon (15). Battles, explosions/remote violence and strategic developments are the most common events in the South (71 battles) and Bekaa. Most battles in the country were recorded in the South due to the Israeli army's continuous attacks and violations. Baalbek–El Hermel also recorded a considerable number of battles and explosions (126 and 130, respectively) and the most violence against civilians (30 cases). Battles and strategic developments are the most common form of events in Akkar, while in Nabatieh the most frequent events were explosions/remote violence. Similarly to the South, the Nabatieh governorate suffered from air/drone strikes and remnants of previous wars.

All eight governorates had suffered armed incidents. While these worsen political instability, handicap national security, and burden the country's economy, the UNDP (2007) found that the frequency of these battles caused acute biophysical alterations to the environment. Abdallah et al. (2018) performed several field campaigns throughout Lebanon as part of a national agricultural risk assessment. In the interviews conducted in the South and Nabatieh, farmers reported losses during both the conflict and post-conflict periods. Most of them reported complete loss of their agricultural lands, permanent damages to soils, and the destruction of terraced lands. Some farmers were able to restore their lands, while others reported not being able to cover the restoration costs and having to abandon what was their main source of revenue. These observations confirm Abu Hammad and Tumeizi's (2010) findings that armed conflicts in some cases have irreparable effects on agriculture and LU/LC. As mentioned in Baalbek–El Hermel, following the conflicts with terrorist groups, several informal settlements expanded. In this case, the conflict-driven LU/LC change solidified Mubareka and Ehrlich's (2010) observations by increasing the population's vulnerability as revealed in indicators 1 and 2. A major event in Beirut, the August Beirut Port explosion, completely transformed the situation. Around 85 per cent of the country's cereal reserve was lost and critical infrastructure needed for ensuring food supplies reach the needy population was devastated (OCHA, 2020).

While armed conflicts directly influence land degradation in the short and long term, prospecting the effect of future shocks is important since these can shift the current land use/cover context to other patterns (Baumann and Kuemmerle, 2016). For that purpose, strategic developments between 2019 and 2020 were analysed, following the recommendations by Raleigh et al. (2010), to anticipate the potential changes in future violence, protests and political patterns. The year 2019 recorded the most strategic developments with considerable displacements from the return of Syrian refugees to Syria, which was made possible by the following factors: i) the facilitated returns through the Lebanese Directorate of General Security; ii) the relative lull in the fighting in Syria; and iii) the recent economic crisis of Lebanon that triggered food insecurity in a large fraction of the Syrian population (WFP, 2020). Other events included tension on the southern border and minor incidents.

With Lebanon's deteriorating situation, continuous political shocks, incapacitation of institutional and societal systems and wider inequalities, fears of conflict eruption are circulating throughout the country. In some regions of the Jbeil district, land has become a central point of conflict between different communities due to tenure-related issues. In this context, land disputes are being used as part of communal identity and culture, hence making lands both a central element and a driver of conflicts (United Nations Interagency Framework Team for Preventive Action, 2012).

4.6 Indicator 6: land use and land cover changes

According to the adapted CORINE land use/ cover classification, 69 classes make up Lebanon's landscape, grouped into five categories:

- **Urban-Artificial classes:** Airport, archaeological sites, cattle raising farms, urban fabric (low, medium, high density), informal urban fabric (low, medium, high density), diverse equipment, dumpsites, green sports areas, green urban areas, highways, industrial or commercial areas, landfill sites, mineral extraction sites, port areas and basin, poultry breeding farms, railway station, tourist resorts, urban extension/ construction sites, urban sprawl (on clear wooded lands, on dense wooded lands, on field crops, on permanent crops, on protected agriculture, on scrublands), and urban vacant lands.

- **Agricultural areas:** Banana trees, citrus fruit trees, field crops in small and medium to large terraces, fruit trees, olives trees, protected agriculture, vineyards and agricultural equipment.

- **Natural classes:** Clear and dense Cedar forests, clear and dense Cypress forests, clear and dense Fir forests, clear Juniper forests, clear and dense Oak forests, clear and dense Pine forests, clear and dense mixed wooded lands, clear and dense other-types of broadleaved trees, clear grasslands, scrublands, and scrublands with bigger dispersed trees.

- **Unproductive areas:** Abandoned agricultural lands, bare rocks, bare soils, burnt wooded lands and rock outcrops.

- **Water bodies:** Hill lakes, inland and marine wetlands, lakes, rivers, rocky and sandy beaches.

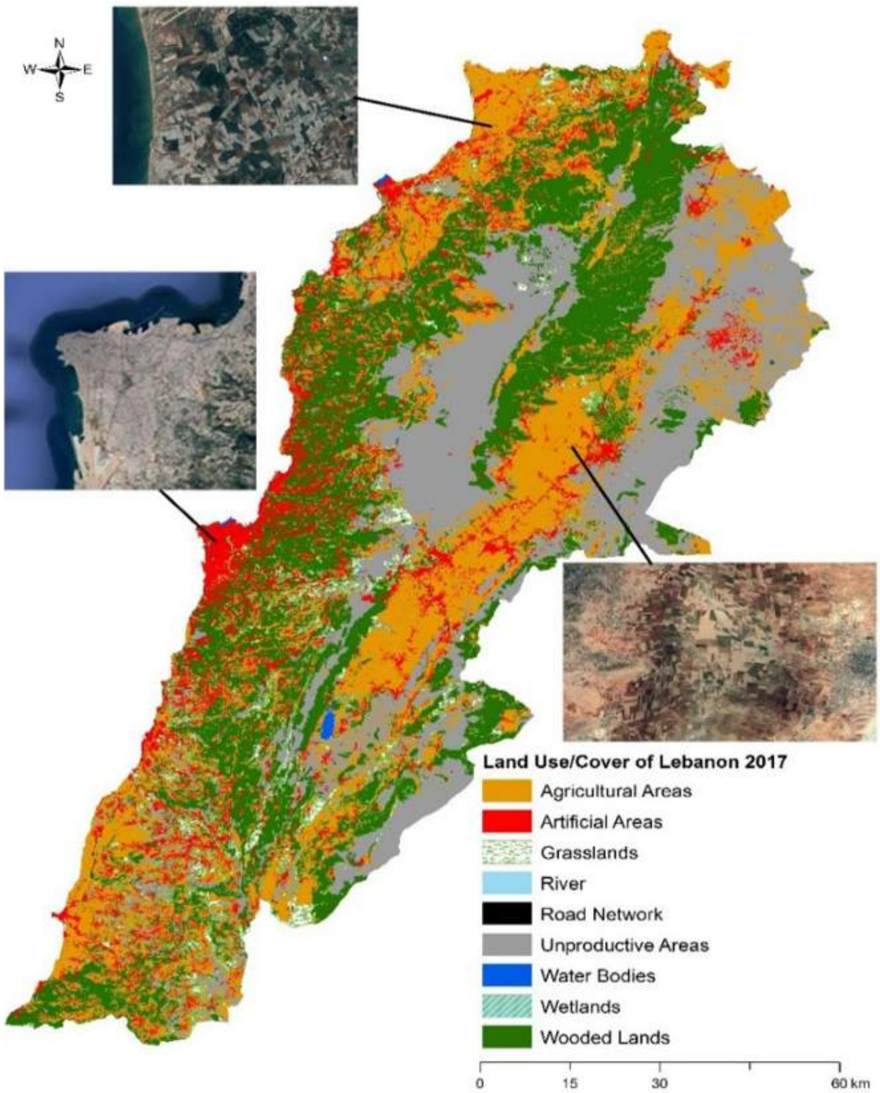


Figure X: Land use/cover map of Lebanon 2017. Source: Faour and Abdallah (2018).

Figure X displays an interlocking mosaic of land occupation classes. In 2017, the LU/LC setting of Lebanon was divided as follows: 11.83 per cent urban-artificial classes, 27.82 per cent agricultural areas, 33.86 per cent natural classes, 26.1 per cent unproductive areas, and 0.39 per cent water bodies. While a more or less homogeneous repartition is prevalent, a typical Mediterranean unequal spatial distribution of classes is observed. Accordingly, agricultural areas are concentrated in the northern inner regions of the country and, to a lesser extent, in the southern parts. The Bekaa plain, lying between the largest unproductive areas of the country (the Mount Lebanon and Anti-Lebanon mountain ranges) has the greatest concentration of agricultural spaces in the country. Urban cover and its associated activities are scattered throughout the country but are particularly aggregated in the coastal regions and the Greater Beirut area. Natural classes (forests, grass, and scrublands) are widely scattered throughout the country. Despite their relative abundance, natural areas are only a shadow of what existed in the previously named "Green Lebanon" and are no more than fragmented remains or patches. According to Masri (1995), the forests of Lebanon were considered limitless as they almost covered the whole territory. Therefore, the 33.86 per cent distribution consisting of 61.47 per cent forests, 12.22 per cent grasslands and 26.31 per cent scrublands reveals the severity of natural cover decline in Lebanon. To determine the evolution of each category, an in-depth analysis of each class during the 2013–2017 period was performed (Table VII).

Land use/cover classes		Area 2013 (km²)	Area 2017 (km²)	Net changes (2013–2017)	Win/loss High point/ Low point
Urban- Artificial classes	Airport	12.15	12.21	0.06	
	Archaeological sites	0.94	0.90	-0.04	
	Cattle raising	2.63	2.75	0.11	
	Low-density urban fabric	237.04	259.71	**22.66**	
	Medium density urban fabric	459.37	500.10	**40.72**	
	Dense urban fabric	138.07	144.96	**6.89**	
	Low-density informal urban fabric	2.95	4.17	1.21	
	Medium density informal urban fabric	1.77	3.31	1.54	
	Dense informal urban fabric	5.30	7.09	1.79	
	Diverse equipment	23.12	23.62	0.50	
	Dump sites	2.84	3.06	0.22	
	Green sports areas	2.50	2.65	0.15	
	Green urban areas	4.11	4.10	-0.01	
	Highway	11.83	11.86	0.03	
	Industrial or commercial areas	48.51	50.52	2.00	
	Landfill sites	0.27	1.49	1.21	
	Mineral extraction sites	59.66	63.55	3.88	
	Port areas	3.50	3.42	-0.07	
	Port basin	5.13	4.14	-1.00	
	Poultry breeding	3.44	3.59	0.15	
	Railway station	0.05	0.05	0.00	
	Tourist resorts	6.82	6.88	0.06	
	Urban extension and/or construction sites	32.63	45.63	**13.00**	
	Urban sprawl on clear wooded lands	1.80	2.10	0.30	
	Urban sprawl on dense wooded lands	4.04	5.20	1.16	
	Urban sprawl on field crops	15.29	19.45	4.16	
	Urban sprawl on permanent crops	14.90	17.90	3.00	
	Urban sprawl on protected agriculture	0.08	0.10	0.02	
	Urban sprawl on scrublands	7.59	9.34	1.75	
	Urban vacant lands	0.79	0.88	0.09	
	Total	1,109.12	1,214.73		

Land use/cover classes		Area 2013 (km²)	Area 2017 (km²)	Net changes (2013–2017)	Win/loss High point/ Low point
Agricultural areas	Banana	36.29	38.47	2.18	
	Citrus fruit trees	153.38	143.08	**-10.30**	
	Field crops in medium to large terraces	1,153.41	1,137.80	**-15.62**	
	Field crops in small fields/terraces	234.45	239.64	5.19	
	Fruit trees	530.99	518.76	**-12.23**	
	Olives	684.89	666.29	**-18.61**	
	Protected agriculture	34.11	41.95	7.83	
	Vineyards	70.02	68.91	-1.11	
	Agriculture equipment	0.88	1.05	0.16	
	Total	**2,898.42**	**2,855.95**		
Natural classes	Clear Cedars	2.06	2.06	0.00	
	Dense Cedars	9.71	9.71	0.00	
	Clear Cypress	15.22	15.04	**-0.18**	
	Dense Cypress	2.24	2.23	**-0.01**	
	Clear Fir	2.86	2.85	**-0.01**	
	Dense Fir	5.94	5.89	**-0.06**	
	Clear Juniper	121.24	120.67	**-0.57**	
	Clear Oaks	870.34	864.63	**-5.71**	
	Dense Oaks	337.09	329.85	**-7.24**	
	Clear Pines	119.66	118.10	**-1.55**	
	Dense Pines	132.12	129.21	**-2.90**	
	Clear mixed wooded lands	276.84	274.43	**-2.42**	
	Dense mixed wooded lands	255.31	251.17	**-4.14**	
	Clear–other types of broadleaved trees	5.95	5.97	0.01	
	Dense–other types of broadleaved trees	4.93	4.93	-0.01	
	Clear grasslands	434.43	424.61	**-9.82**	
	Scrublands	350.27	343.68	**-6.59**	
	Scrubland with some dispersed bigger trees	578.32	570.83	**-7.49**	
	Total	**3,524.53**	**3,475.86**		
Unproductive areas	Abandoned agricultural lands	113.58	110.85	-2.72	
	Bare rocks	2,089.40	2,084.17	-5.23	
	Bare soils	113.54	113.63	0.09	
	Burnt wooded lands	6.05	10.85	**4.80**	
	Rock outcrops	368.70	360.03	-8.67	
	Total	**2,691.27**	**2,679.53**		
Water bodies	Hill lakes	3.85	4.00	0.15	
	Inland wetlands	4.05	4.02	-0.03	
	Marine wetlands	1.03	1.03	0.00	
	Lakes	11.72	9.71	-2.01	
	Rivers	15.26	14.82	-0.44	
	Rocky beaches	1.93	1.91	-0.02	
	Sandy beaches	3.83	3.83	-0.01	
	Total	**41.67**	**39.32**		
National total	**km² 10,452**				

Table VII: Changes in area according to land use and land cover classes (2013–2017)

Several conclusions can be extracted from Table VII. During a span of only four years, considerable changes were observed, particularly within the urban-artificial, agricultural and natural categories. In the urban-artificial categories, striking increases are observed in the low-density urban fabrics, medium density urban fabrics and dense urban fabrics. These findings suggest that urban fabric densification has considerably intensified in the last three years. Moreover, the increase of urban extension sites and sprawls (+23.48 km^2) reveals additional rapid urbanization in the country. At a combined state, the sum of all urban covers dramatically increased by 105 km^2 within four years, at the expense of other classes, namely the agricultural and natural categories. Accordingly, a combined decrease of 91 km^2 of these areas (-48.86 km^2 and -42.5 km^2, respectively) was observed. Within the agricultural classes, field crops in medium to large terraces, citrus fruit trees, olives, and fruit trees showed the most significant declines. To determine if these decreases resulted from agrarian abandonment, the net change of areas for abandoned agricultural lands was considered. With reference to Table VII, the decreases of abandoned agricultural lands, rather than their increase, negates this hypothesis. Therefore, losses of agricultural areas can be attributed to the expansion of the urban cover. The findings of indicator 1 solidify this hypothesis as urban development was shown to have significantly encroached on the country's arable lands (531 km^2 in 2013 and 579.38 km^2 in 2017).

Natural classes have also witnessed countable changes. Within this category, oaks and mixed wooded lands (clear and dense) suffered from the most significant decreases, followed by the scrub and grasslands, respectively. While urban encroachment, unsustainable management, land clearing, and to a lesser extent armed conflict are the main reasons for these losses (MoA, 2015), the contribution of wildfires should not be overlooked. Accordingly, burnt areas showed considerable increases by a rate of 1 km^2/year (see wildfire indicator section for further analysis). While the analysis in Table VII revealed ample changes during the four-year period, deeper insights are needed to infer land degradation. To accurately present land degradation, a comprehensive evidence-based approach is needed. As mentioned previously, not all forms of expansion or changes necessarily cause land degradation. Instead, some changes may be suitable when viewed with respect to the land potential angle. Al-Sayah et al. (2019) defined a few guidelines to determine the adequacy of the land cover based on the lands' suitability. Accordingly, the expansion of urban cover and its associated activities over prime lands (I and II) are considered as an unsuitable distribution, often causing irreversible land degradation. Agricultural expansion over nonarable lands (III and IV) is considered as a form of land overuse (lands used in a manner that exceeds their capabilities), while the presence of unproductive classes over prime lands is a form of land loss potential (land underuse).

Within the natural classes, the occurrence of forests over any land capability class is considered suitable, while the presence of grass and scrublands over prime lands is considered as land underuse. This conception is due to the fact that grass and scrublands do not support biodiversity, generate biomass, and recharge soil organic content and as much as forests do. The availability of fertile lands covered by grasslands can be a high ecological indicator for a balanced ecosystem and natural recharge in case of overproduction of food crops and availability of expanding soil areas. However, national food security and environmental concerns are equally important, that is why the specific use of each soil type was evaluated based on land suitability (from land capability) with special attention paid for ecosystem functions. The evolution of each LU/LC category with respect to land capability classification is presented in Table VIII.

LCC LU/LC	I 2013	I 2017	II 2013	II 2017	III 2013	III 2017	IV 2013	IV 2017
Urban-Artificial	277.51	307.85	253.53	271.53	102.55	113.20	468.70	514.96
Agricultural	1,115.89	1,095.08	475.03	467.55	399.97	397.10	902.82	891.65
Natural	246.79	240.35	551.09	544.16	254.22	251.30	2,463.44	2,431.11
Unproductive	252.49	249.76	200.46	196.73	965.62	960.77	1,262.36	1,261.84

Table VIII: Distribution of land use and land cover categories over land capability classes (km2)

The findings allowed categorization of land use into the following classes:

a) Underused lands: In 2013 unproductive classes on prime lands, in addition to agricultural classes on non-arable lands occupied 1,755.74 km^2. Additional land underuse is caused by the presence of scrubs and grasslands on prime lands (214.33 km^2 on class I and 329.40 km^2 on class II). Consequently, 2,299.47 km^2 of lands, accounting for 22 per cent of the country, were underused. In 2017, land underuse due to these criteria decreased by 30.59 km^2 to become 2,268.88 km^2 (21.70 per cent of the total).

b) Irreversibly degraded lands: These represent the urban-artificial areas covering arable lands. Reversing land degradation in this case is not possible, and this category represents lands that are degraded beyond restoration. In 2013, urban cover on arable lands totalled 531.04 km^2, while in 2017, urban cover expanded by 48.34 km^2 to cover 579.38 km^2. This increase covers 5.54 per cent of the country and reflects the absence of land use planning, highlighting the continuous urban encroachment on arable lands and solidifying the role of urbanization as a national land degradation driving force.

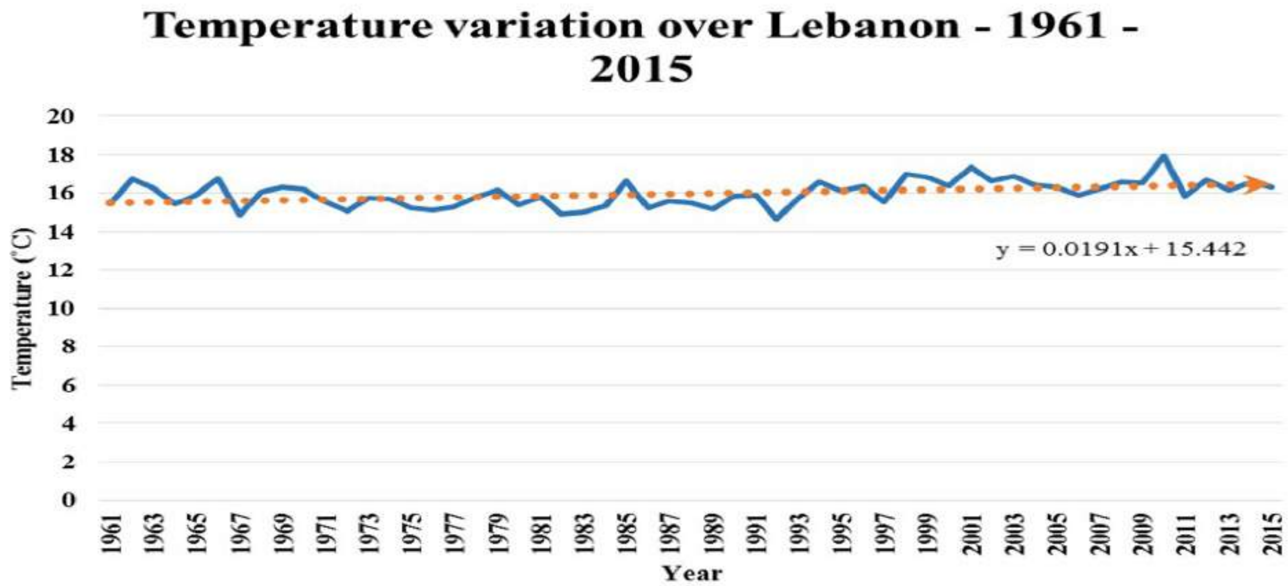
c) Lands used within their capabilities: These represent urban-artificial areas and unproductive categories overlaying non-arable lands, forests over any land capability class, and agricultural classes overlaying prime lands. In 2013 lands used within their capabilities accounted for 7,255.11 km^2 (69.41 per cent of the country), while in 2017 these were 7,240.35 km^2 (69.27 per cent). According to these numbers, 14.76 km^2 of adequately used lands were lost in four years (a rough estimate of 3.7 km^2/year).

The decline of land underuse can be considered as a positive land reclamation sign despite its slow rate. However, the decrease of lands being used within their capabilities and the increase of irreversibly degraded lands highlight considerable land loss. The two above-mentioned land use categories (b and c) can be used to infer land degradation since land underuse is a form of land productivity loss (Stocking, 2001), while the irreversibly degraded lands reveal irrevocable losses. As a result, significant stress on natural resources is being manifested due to unsustainable land use planning, hence the need for a different approach.

4.6.1 Climate change

Since land degradation is driven by natural and anthropogenic factors, the contribution of climate change must not be overlooked. However, given the time frame of this study (2011–2020), a complete climatic cycle cannot be represented. Nonetheless, to ensure a complete national land degradation profile, an analysis of temperatures and precipitation changes in Lebanon was performed. According to climate predictions from the Providing REgional Climates for Impacts Studies (PRECIS) model for Lebanon, coastal temperatures will rise by 1°C, while the mainland will exhibit a 2°C increase by 2040. Increasing trends will progress further until 2090 where additional 3.5 to 5°C are projected (Farjalla et al., 2014). On the other hand, precipitations will follow a decreasing trend particularly during winter due to the northward shift of the mid-latitude storm track (Trærup and Stephan, 2015). This will result in a decrease of precipitations by 10 to 20 per cent by 2040, and 25 to 45 per cent by 2090, along with the significant intensification of erratic precipitation (Farjalla et al., 2014). To observe these changes, the historical evolution of temperature and precipitation data of Lebanon was studied (see Figure XI).

The average temperature for the 1961–2000 period (15.7°C) was compared with 2000–2015, revealing an increase of 0.8°C. The rate of increase was found to be faster than the global average (UNFCCC, 2007). Subsequent increases of drought periods are also projected over the entire country. These are expected to become longer by 9 days by 2040 and by 18 days by 2090 (MoE, UNDP and GEF, 2016). Temperature rises and precipitation decreases will additionally result in 43 days with mean daily temperature above 35°C and a continuum of dry consecutive days leading to seasonal prolongation (MoE, UNDP and GEF, 2016). These changes will shift the Lebanese climate from moderate to hot/dry and subsequently drive the cycle of increased droughts elevating risks of desertification, which in turn leads to land degradation (UNCCD, 2008).



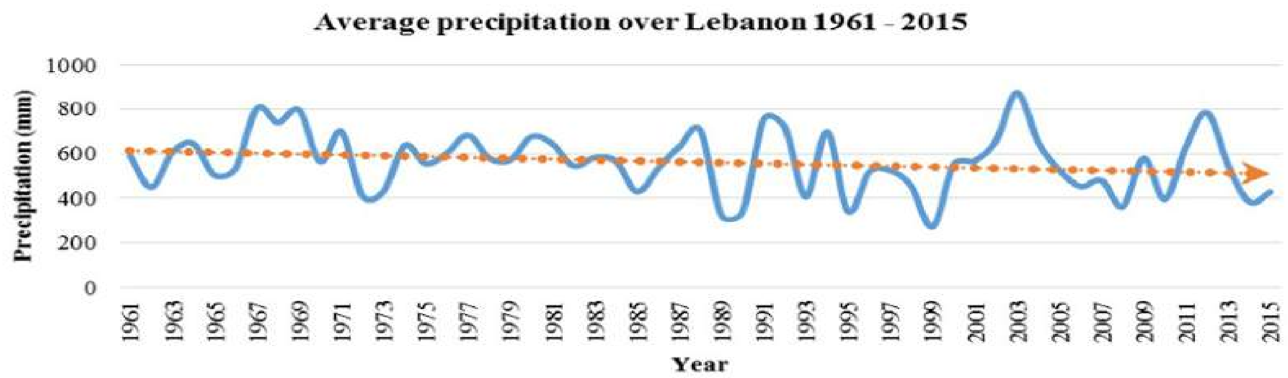


Figure XI: Average temperature (a) and precipitation (b) between 1961 and 2015. Source: World Bank climate database.

4.7 Indicator 7: wildfires

The September to November interval characterized by high temperatures, strong winds, and low soil moisture is the most active wildfire period in the country. As of 2010, wildfires became a recurring disaster in Lebanon with far-reaching implications. The October 2019 wildfire events were one of the most intense episodes ever witnessed, as more than 100 fires ravaged Lebanon, and assistance from neighbouring countries was requested. October 2020 was no different, with wildfires erupting all over the country, causing irreversible damage to biodiversity, soils, biomass and lands.

The CNRS-RSC wildfire database provides an itemized record of fire-induced losses and generates wildfire potentiality maps. The importance of this dataset lies in the detailed outputs it generates and its fine scale representation. Both factors are achieved through the incorporation of several factors such as topographic base parameters, road network and cities proximities, land occupation maps, vegetation fire intensity properties, past events, and crowdsourcing. For this indicator, the CNRS-RSC wildfire database was used to extract the location of the fires and their associated damages with respect to the following classes: agricultural spaces, grasslands, and forests (Figure XII, XIII and XIV).

Fires in agricultural areas were extracted since in their aftermath food security and the lands' productive capacity are impaired. Grasslands and forest fires were studied due to a) their detrimental effects on vegetation cover; b) the changes they cause to soil/ land properties; and c) their exacerbating effect on soil erosion rates during post-fire phases (Vieira et al., 2018).

As shown in Figure XII, the most significant agriculture fires occurred in the Zahle district of the Bekaa governorate, the Sour (Tyr) district of the South governorate, the Akkar district of the Akkar governorate, and the Zgharta district of the North governorate. These fire-induced losses and subsequent land degradation further aggravate the strained conditions in the Bekaa and Akkar governorates and compound losses in others. A remarkable feature is the recurrence of these fires in the above-mentioned hotspots (11 to 20 fires and more than 20 fires over only 3 years). Considering the importance of the Bekaa, Akkar and South governorates in terms of agricultural contribution and national food security, better precautions should be taken. Further, appropriate response and mitigation strategies and measures should be invested in these areas to prevent further occurrence.

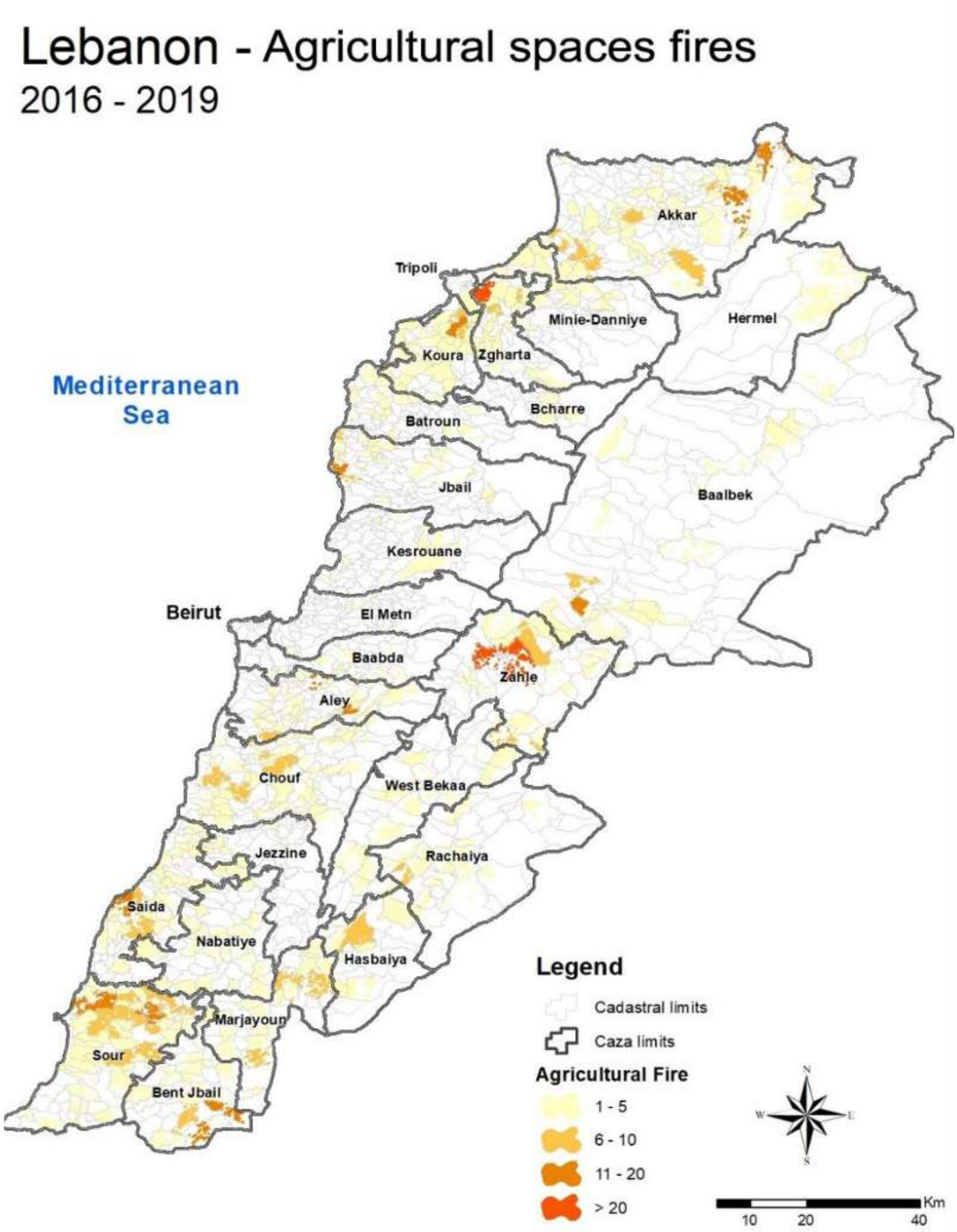


Figure XII: Agricultural fires in Lebanon (2016–2019).

Forest fires are widespread, affecting almost every governorate in the last four years (see Figure XIII). Visibly, Mount Lebanon and Akkar are the worst hit regions, with around 20–50 and 50 fires, respectively. These losses combined with urban expansion–induced deforestation are key land degradation drivers in the country. Knowing that Lebanon established a national strategy for forest fire management in 2009, the frequent occurrence of these fires reveals several alarming elements: a) the ineffectiveness of fire law enforcement (Faour et al., 2004), b) the absence of preventive measures, and c) the mismanagement of forests. Moreover, limited human and fire-fighting resources are additional shortcomings in the fight against wildfires. Municipalities play an important role by allocating resources (manpower, water tanks, water outlets and other equipment) as well as raising awareness, pruning, cleaning understories, etc.

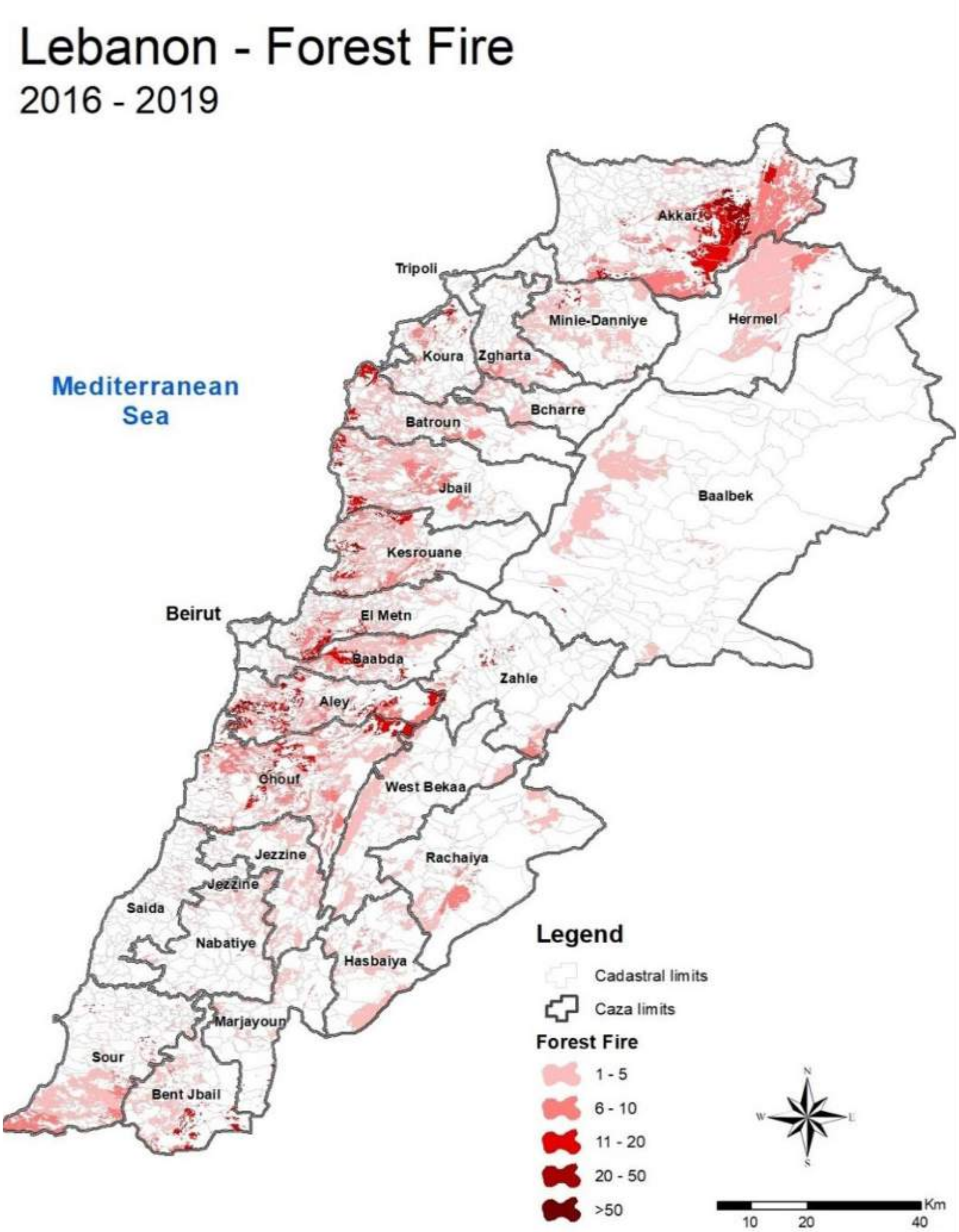


Figure XIII: Forest fires in Lebanon (2016–2019).

As seen in Figure XIV, grass fires are less frequent than forest and agricultural fires in Lebanon. Most occurred in the Marjaayoun district of the Nabatieh governorate and the Aley district of Mount Lebanon. While relatively less frequent than the other types of fires, grassland losses are equally detrimental to the environment as they destroy biodiversity and expose barren soils.

The relationship between land degradation and wildfires is not short-termed but rather lasts for extended periods of time. The short-term effects of wildfires encompass loss of biomass and vegetation cover. While these damages may be reversed in the short term, losses are much heavier in the long term. This is due to the fact that wildfires cause irreversible alterations to soil properties (organic matter and nutrients), landscape quality, ecosystem services, and increase soil erosion risks/land vulnerability. For these reasons, wildfires are considered a powerful land degradation driver (Esteves et al., 2012)including southern European Mediterranean countries. Identification of integrated conservation approaches that can reduce or prevent degradational impacts is the aim of the EU-funded DESIRE research program, part of which is concerned with quantifying the likely benefit of acceptable alternative conservation strategies to wildfire. The overall aim of this paper is to apply a modification of the Pan-European Soil Erosion Risk Assessment (PESERA. The observations from this indicator converge with those made by IOM and UNCCD (2019), where lands in Rachaya (97.4 per cent), West Bekaa (90.4 per cent), Zahle (83.3 per cent), and Baalbek (73.2 per cent) were reported to be under moderate to high risks of desertification as a result of wildfires, among other factors. Therefore, wildfires must be high on Lebanon's agenda to safeguard against further environmental and economic losses.

Figure XIV: Grassland fires in Lebanon (2016–2019).

4.8 Indicator 8: socioeconomic parameters

Recently, the socioeconomic angle has become a critical concern and a threat to Lebanon's development gains. The country's acute 2019-2020 ongoing economic crisis was greatly worsened by the COVID-19 pandemic. While the biophysical indicators directly influence land degradation, the relationship of socioeconomic parameters and land degradation is not straightforward. The rationale behind this logic is that land degradation can be both a cause and consequence of socioeconomic transformations (Gerber et al., 2014). As mentioned in the literature review section, some of the most influential socioeconomic factors are: economic capacities, unemployment, food demand, household income levels, population increase, migration, and poverty. The food production and security aspects of land degradation are most affected by changes in socioeconomic conditions.

To investigate these effects in Lebanon, based on detailed concrete evidence, a timeline of the country's eventful economic cycle is presented. For that purpose, the work of Mazzucotelli (2020), one of the most up-to-date detailed reviews (1948–2020) of the Lebanese economic sector was used. According to Mazzucotelli (2020), due to the liberalization of currency and capital markets in 1948, and the 1956 banking secrecy law, Beirut attracted Egyptian and Syrian capital, making it a regional centre for financial operations. During the 1970s oil money from the Gulf states flooded Lebanon, to the point where the ratio between bank deposits and national income became 122 per cent in 1974. The year 1975 marked the start of the unending Lebanese war. In 1982 the Israeli invasion of Lebanon destroyed the Lebanese economy, and public debt grew without control. As a result, significant economic inflation settled and the United States Dollar (USD) became a powerful means of economic exchange in the country. During that period, Lebanese soils and lands were being destroyed at unprecedented rates. It was not until the post–civil war period that economically driven land degradation began. Figure XV provides a timeline of economic events in the country, starting from the late 1990s until 2020, according to Mazzucotelli's (2020) review.

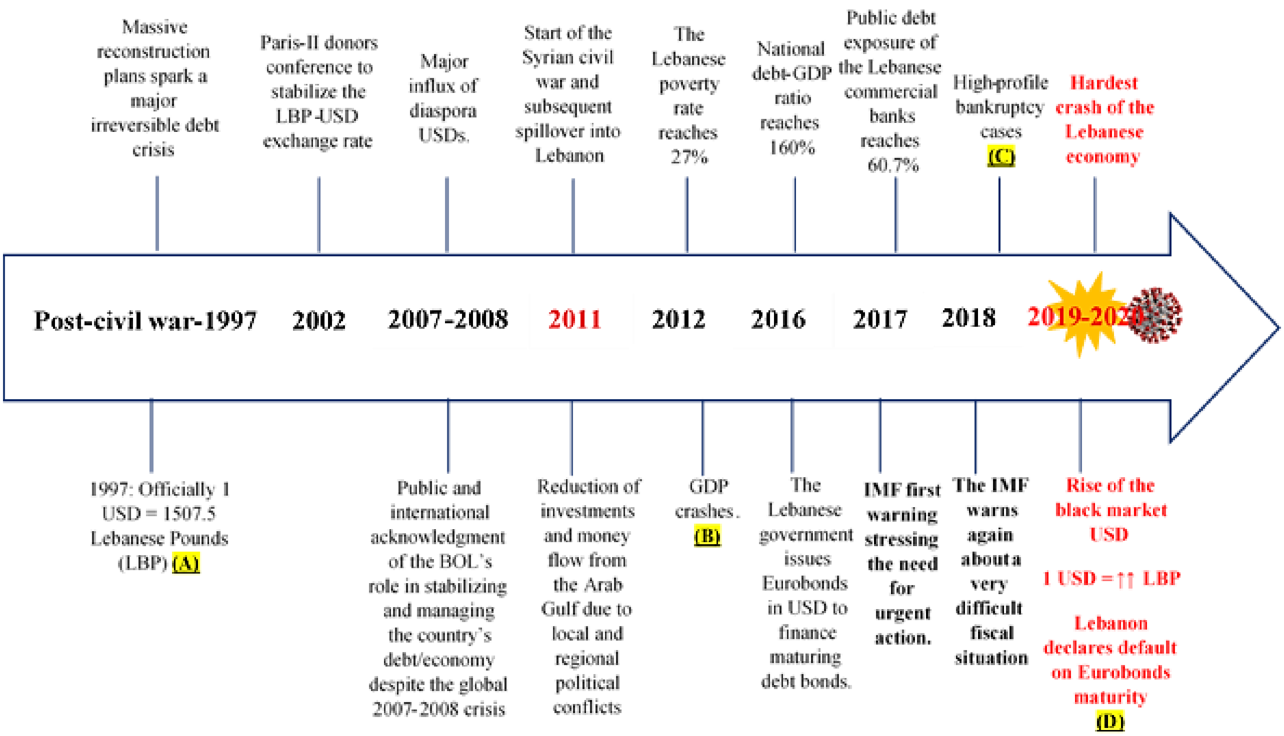


Figure XV: Key economic events in Lebanon (1997–2020).

(A): In 1997, the Bank of Lebanon fixed the Lebanese Pound (LBP) exchange rate to the USD at 1,507.5 to 1 (Bank of Lebanon, 2012). While this step contributed to the economic stability of the country, it initiated the first aspects of the long-term food security imbalance. As reported by Mazzucotelli (2020), the newly fixed LBP-USD rate made the import of goods and services more lucrative than producing them domestically. The food production sectors in Lebanon (the agricultural and industrial sectors) were marginalized with around 80 per cent of the country's food being imported (Halabi and Ghanem, 2016). Lebanon fell behind in the quest to achieve SDG 2 Zero Hunger and faced a long-term food security threat due to being import dependent. With the 2019–2020 economic crisis, this weak point became very apparent and tangible. Lebanon's trade balance highlights this problem (see Figure XVI), as a considerable fraction of imports is food.

(B): Following the Syrian crisis and the subsequent spillover, Lebanon's GDP crashed and has kept on decreasing ever since. Since GDP reflects the economic progress of a country, Figure XVII highlights Lebanon's precarious situation. Several factors have contributed to this drop, namely internal corruption, excessive migration, the reduced in-flow of Gulf money due to political conflicts, and local political shocks. Abdallah et al. (2018) attributed a considerable part of this shock to the forced closure of the borders between Lebanon and Syria, and hence the complete disruption of Lebanon's export to the Arab world. As a result, several farmers abandoned their agrarian activities and reoriented themselves towards other more lucrative occupations. Having discussed the effect of agrarian abandonment on land degradation in previous indicators, an aggravation of land degradation is expected. When considering local GDPs, reduced contribution from the agricultural sector in contexts like the Bekaa, Akkar and South governorates where agriculture contributes up to 80 per cent of the regions' GDPs (FAO, 2020) initiates a vicious cycle: compounding much heavier losses, leading to further income shortages, increasing poverty, fuelling insecurities, escalating food conflicts, unsustainable changes in LU/LC practices, and finally uncontrolled land degradation.

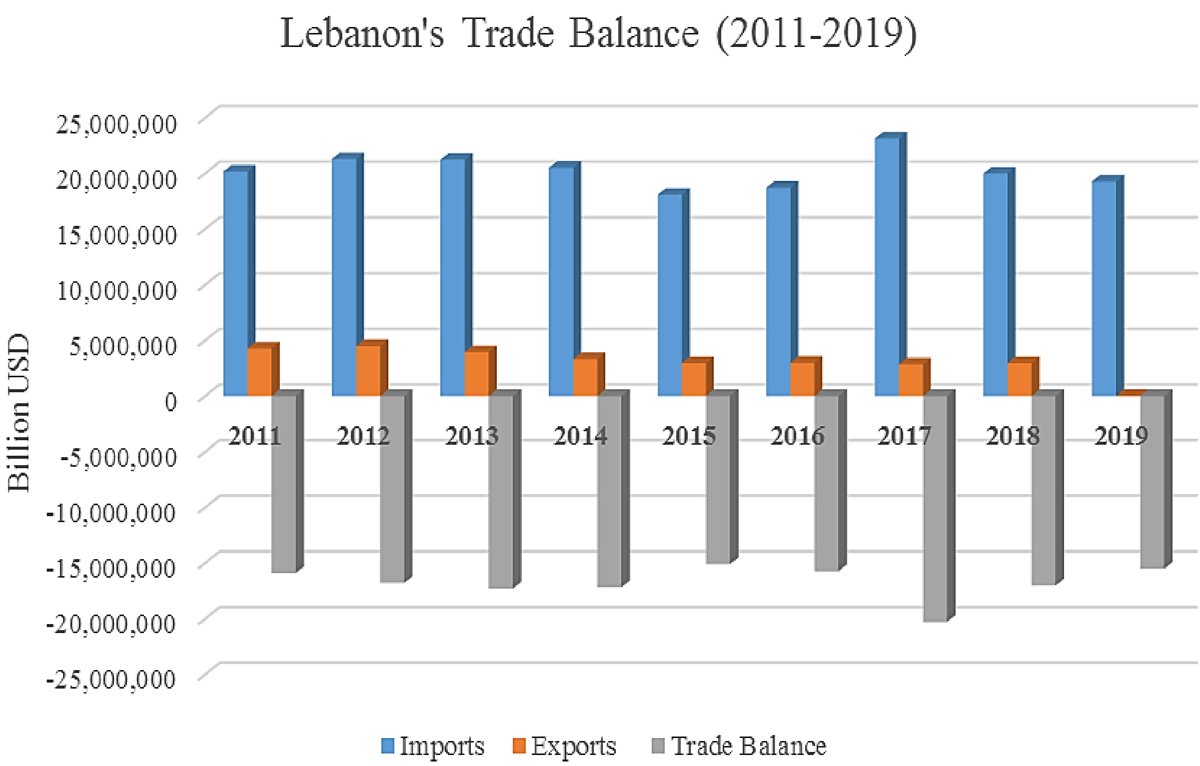


Figure XVI: Lebanon's trade balance (2011–2019).

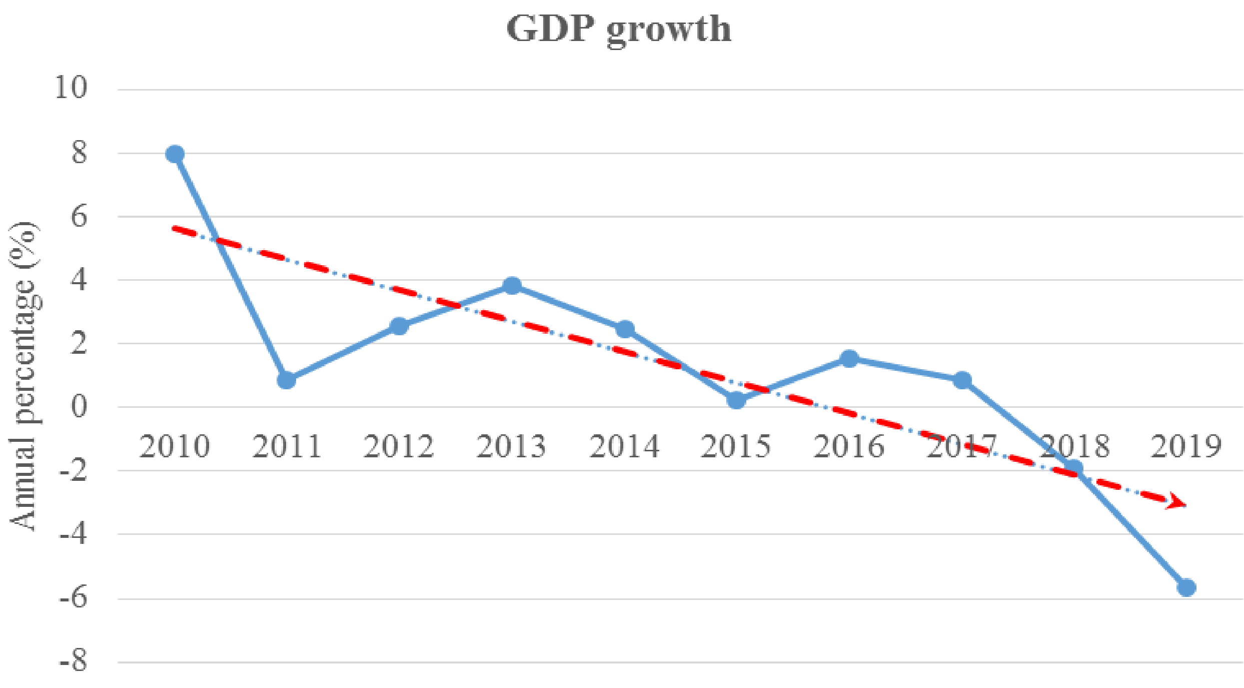


Figure XVII: Lebanon's GDP growth (2010–2019).

(C): Due to national and international political, security and economic distrusts, tourism in Lebanon sharply declined. Knowing that Lebanon's economy heavily relies on the tourism and services sector (Abdallah et al., 2018), the quasi-deficiency of Gulf capital and the reduced inflow of Lebanese diaspora money worsened the already difficult situation (Mazzucotelli, 2020). While these events do not directly relate to land degradation, they paved the way to the 2019–2020 catastrophic period.

(D): According to economic experts, World Bank and IMF, the 2019–2020 economic crisis is by far the hardest shock to the Lebanese economy. The 2019–2020 period is almost as eventful as the entire Lebanese economic history; the economy abruptly crashed due to the never-ending cycles of corruption, bribery, profiteering, fraud and extortion. The chain of events was striking: the Lebanese government defaulted on Eurobonds maturities; the unemployment rate exploded; salaries decreased abruptly; the October 17 revolution erupted; shortages of USD in banks were reported, leading to a destabilization of a heavily dollarized economy; food and merchandise prices soared; an unofficial LBP-USD rate created a black market for USD; the government requested an IMF intervention; haphazard banking limitations on depositors (informal cuts and capital control) were imposed; two governments resigned; shortages of food and fuel supplies ravaged the country, and the ongoing national security destabilizations continued. Amidst all the chaos, the COVID-19 pandemic and August 2020 Beirut Port explosion delivered a coup de grâce to an already dying economy. Each cited element and its effect are explained in greater detail below.

When the Lebanese government defaulted on Eurobonds maturity (public debt), the capacity of the Lebanese authorities to provide for and fulfil the citizens' needs was greatly weakened. Accordingly, unemployment rates in the country reached new heights and the build-up of staggering economic events gave rise to the October revolution (see indicator 5). According to CAS, ILO and EU (2020), unemployment rates throughout the country were distributed in 2019 as follows: 3.8 per cent in Akkar, 4.2 per cent in Baalbek–El Hermel, 6.4 per cent in El Nabatieh, 6.9 per cent in Bekaa, 8.2 per cent in Beirut, 11.9 per cent in the South, 15.5 per cent in the North and 43.1 per cent in Mount Lebanon.

While the country kept sinking, USD shortages were reported. In Lebanon, shortages of USD directly influence the economy since national and foreign monetary policies are USD dependent. This unstable situation led to the rise of the black market for USD, with exchange rates growing uncontrollably (see

Figure XVIII). As mentioned previously, 80 per cent of the country's food is imported (Halabi and Ghanem, 2016), paid for in USD and sold in LBP. With the fluctuation of exchange rates and the shortage of USD in commercial banks, trade operations were being paid from black market USD. Accordingly, food prices soared and food insecurity expanded throughout the country, while merchandise prices kept changing every week (WFP, 2020). Furthermore, the rupture of fuel imports and distribution further disrupted food supply chains. While black market USD rates continued to escalate, most salaries lost their purchasing power as the LBP devaluated.

According to the Lebanese Consultation and Research Institute (2020), the increases in food and merchandise prices between September 2019 and September 2020 are as follows: +8.33 per cent for medication, +95.87 per cent for bread, +98.73 per cent for fruits, +106.34 per cent for vegetables, +111.54 per cent for eggs and dairy products, +155.87 per cent for oils, +158.93 per cent for meat and poultry, and +234.53 per cent for sugar and confectioneries. Heavily impacted by these increases, WFP (2020) reported a growing willingness of several displaced communities to return to their home countries.

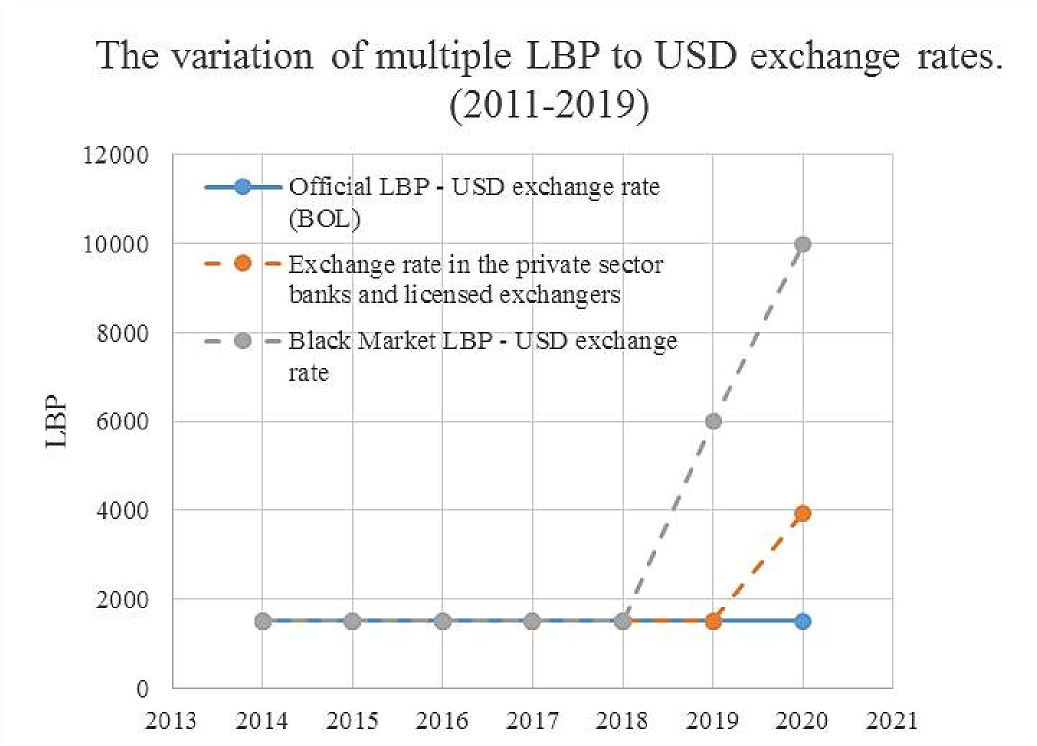


Figure XVIII: Formal and informal USD-LBP exchange rates.

The impacts of COVID-19 and its associated lockdown further aggravated the already deteriorating situation. WFP's (2020) assessment of the COVID-19 and economic crises of Lebanon demonstrated that i) two out of three Lebanese households had less incomes; ii) during the COVID-19 lockdown, one out of every three Lebanese became unemployed, and iii) the cost of the food basket increased by half between mid-March and May. High food prices threaten not only food security (Gustafson, 2013) but also public security as WFP (2020) reported escalated food related tensions in Lebanon. The Beirut Port explosion only made matter worse with 85 per cent of the country's cereal stockpile going up in smoke (OCHA, 2020). Moreover, the destruction of the Beirut Port caused an estimated loss of USD 15 billion, hampered import activities, and widened socioeconomic gaps (OCHA, 2020). Further concerns are being expressed as a 14 per cent decrease of GDP growth is expected for 2020 (WFP, 2020) and certain adverse measures are anticipated, for example, the removal of governmental support on merchandise and fuel. Therefore, the socioeconomic situation will most likely deteriorate even further. The ongoing and expected scenarios will fuel further inequalities, tensions, conflicts, food insecurity, resource scarcity and ultimately economically driven land degradation.

As the 2030 SDG horizon comes closer, Lebanon is still handicapped by many challenges. Land degradation is progressing at uncontrolled rates in an already small country with limited land capital. In an effort to safeguard what remains of Lebanon's lands, this study proposed a set of hybrid indicators (biophysical and socioeconomic), to provide the first detailed national review of land degradation. The methods introduced in this study were also carefully selected to ensure replicability in other Arabian and Mediterranean contexts. Accordingly, eight indicators were proposed: (1) the expansion of urban cover/informal settlements and their position with respect to land capability classes; (2) population change (residents and non-residents); (3) agrarian abandonment with respect to land capability classes; (4) quarry cover expansion with respect to land capability classes; (5) conflicts and exceptional events; (6) land use/cover and climate change impacts, (7) wildfires and their associated damages, and lastly (8) socioeconomic aspects including the COVID-19 pandemic.

Indicator 1. Expansion of urban cover and informal settlements over different land capability classes: In terms of urban expansion, an increase of 105 km^2 was found, with around half occurring on prime lands (classes I and II). The most significant encroachments on arable lands occurred in the Akkar, Baalbek–El Hermel and Bekaa governorates. In Bekaa, the country's food bank, two-thirds of the urban cover developed over class I lands, causing a significant loss of land potential. Extensive informal settlement development exerted additional pressure on the country's lands, with a large fraction covering prime lands. The most affected governorates were also Akkar, Bekaa and Baalbek–El Hermel, with 93 per cent of informal settlements covering Akkar's prime lands, 89.5 per cent in Bekaa, 79 per cent in the South and 57.8 per cent in Baalbek–El Hermel. In the latter, a particularly rapid increase of the informal fabric was observed. Accordingly, considerable changes in each of the low-density, medium density and dense informal fabrics were noted. In addition to their expansion over prime lands and the subsequent reduction of arable land hectare per person, settlement-related practices also add a layer of complexity. That is why waste disposal practices and water consumption were investigated. Waste disposal means are particularly preoccupying given the recent collapse of the waste disposal system. Waste burning, open dumping and waste burial were found to be common practices in several informal settlements. These actions are collectively responsible for increased air pollution, generate leachates and contaminate soil and water resources.

Regarding water consumption, and despite the relative fortunate hydrological position of Lebanon, water stress was already a prevalent concern before 2011. According to Jaafar et al. (2019), an additional 6 per cent of water stress was observed following the mass displacements. At a combined state, the uncontrolled/unplanned urban expansion and the presence of informal settlements are causing land degradation, exacerbating pressures on natural resources and triggering conflict over access to resources.

Indicator 2. Population change: Population data analysis revealed that Mount Lebanon is the most populated governorate in the country. In Akkar, Bekaa and Baalbek–El Hermel, population changes were significant and resulted from Syrian displacement. While population changes influence each governorate asymmetrically, the most vulnerable contexts are expected to be the most affected. Such was the case of the Akkar, Baalbek–El Hermel and Bekaa governorates, where competition for low wage jobs increased the Lebanese workforce's unemployment in the already most fragile governorates.

Indicator 3. Abandoned agricultural lands with respect to land capability classes: Abandoned agricultural lands are serious drivers of land degradation (Gibbs and Salmon, 2015). With increased difficulties, low economic profit, and the loss of fertile lands, agrarian abandonment became common. In a country where 80 per cent of food is imported, the loss of arable lands and agrarian abandonment are threatening food sufficiency and security. In addition to their expansion, a considerable fraction of abandoned agricultural lands covers prime lands (42 per cent), particularly in the Baalbek–El Hermel and Akkar governorates. In addition to the loss of prime land potential (class I and II), land underuse due to abandoned agricultural lands on classes III and IV was revealed. As a result, the role of agrarian abandonment as a driver of land degradation in Lebanon was solidified. An important factor to consider is the particularity of plantations in Lebanon where illegal crops, concentrated mostly in the Baalbek–El Hermel governorate, are prevalent. In a study conducted by Kosseifi (2020) through remote sensing techniques, areas of illegal crops were found to fluctuate between 550 ha and 1,250 ha. The presence of illegal crops in these contexts is a result of socioeconomic, political and hydro-meteorological factors. Several debates regarding the legalization of these plantations in Lebanon are ongoing, but no concrete progress has been made.

Indicator 4. Quarry cover expansion with respect to land capability classes: In a topographically rich country as Lebanon, quarry cover expansion is not surprising particularly with the need to house the growing population. This problem is made worse by bans on aggregates and exclusive permits granted to local companies for using cement for construction. During the studied period, an increase of 10.68 km^2 of quarry cover was found. Regarding their position with respect to the different land capability classes, 17 per cent presence on prime lands in 2005 evolved to 27 per cent in 2017. Accordingly, often irreversible losses of potent lands can be attributed to quarry cover expansion.

Indicator 5. Conflicts and exceptional events: The conflicts and exceptional events indicator solidified the instability of Lebanon. The recent years (2016–2020) revealed more troubled periods, suggesting unstable times ahead. The recorded battles led to several conflict-driven LU/LC changes such in the Baalbek–El Hermel, South and Nabatieh governorates. Other events such as the Beirut Port explosion damaged the country's food stocks and burdened vital import activities. While protests and strategic developments do not directly imply land degradation, they reveal the insecurity and instability of the country in the short and long term. Fuelled by many underlying reasons, this state of unrest engages with land degradation in a directly proportional relationship where one feeds the other (Van Schaik and Dinnissen, 2014). With Lebanon being torn apart between recent geopolitical tides and its already sensitive geographical location, great uncertainties await the country. Consequently, Lebanon's instability will continue to fuel land degradation, while the latter worsens the already precarious situation.

Indicator 6. Land use and land cover changes: LU/LC changes are the most amplified expressions of land degradation. To fully represent land degradation, climate change data was also reviewed. Within a timeframe of only four years, general land occupation dynamics revealed significant densification and expansion of urban fabrics (+105 km^2), coupled with considerable decreases of agricultural and natural areas (-91 km^2 collectively). Consequently, the absence of urban planning schemes was amply revealed. When the LU/LC change layer was intersected with the land capability map, more significant findings resulted in categorizing lands into three classes: underused (21.7 per cent of the total), irreversibly degraded (5.54 per cent), and lands used within their capabilities (69.27 per cent). The area of underused lands slightly decreased between 2013 and 2017; however, the decline in lands being used within their capabilities and the increase of irreversibly degraded lands were also significant. While this progression happened during only four years, better enforcement of land use planning regulations and scientific data–based legislative frameworks are needed. Climate change reviews revealed a clear shift towards hotter and drier conditions. With the prevalence of droughts, desertification and land degradation follow. While Lebanon is considered an exception in the region, the climate change factor – which often becomes tangible after prolonged periods – will cast its weight on land degradation and other environmental processes.

Indicator 7. Wildfires: Wildfires are commonly occurring natural hazards in Lebanon and in other Arab and Mediterranean settings. The integration of this natural hazard was performed to account for the heterogeneity of land degradation and its driving forces. Accordingly, the occurrence of wildfires in agricultural areas, grasslands, and forests was investigated. From 2010 onwards, wildfires have become very frequent in Lebanon. Unlike all other indicators, the effect of wildfires on land degradation is immediate and can persist for prolonged periods. Based on this indicator, forest fires were found to be a major concern for food security, the lands' productive capacity, biomass degradation, and accelerated deforestation. In addition to the direct tangible effects, wildfires are often modifiers of soil and land properties leading to accelerated soil erosion rates during post-fire phases. In Lebanon, wildfires are often intentional and instead of land reclamation, burnt areas are used for urban expansion or agricultural development. Hence, wildfires in Lebanon have both a natural and an anthropogenic dimension in land degradation.

Indicator 8. Socioeconomic parameters: The socioeconomic index is the most directly felt aspect for daily life in Lebanon. With the acute economic situation and additional shocks from the COVID-19 pandemic, national food security is in a delicate state. With GDP in a downfall, World Bank and IMF are projecting further decreases. Accordingly, a sharp economic recession is foreseen. With a small agricultural sector, self-sufficiency is far from reality. With 80 per cent of the country's food imported and paid for in USD, the Lebanese population is suffering from volatile food prices aggravated by USD shortages. Moreover, national unemployment rates have significantly increased, while household purchasing power decreased. These facts incapacitate

Lebanon's long-term food security by making it economically import dependent. With the progression of this crisis, food conflicts are starting to appear and are expected to multiply. Considering the interlinkages between land degradation and food security, and the connection between food security and conflict, subtle effects are anticipated. While socioeconomic changes do not directly influence land degradation, they weaken the adaptive capacity of the population. As a result, the country's vulnerability increased and the available funds for intervention constricted. Ultimately, Lebanon has become less resistant and its adaptation-coping capacities are in jeopardy.

While the eight indicators were related to the study's objective, each index revealed the vulnerability of Lebanon not only to land degradation but to several other environmental and socioeconomic risks. In addition to the alarming findings revealed by each index alone, the interdependence and cascading effects between the eight indicators uncovered daunting feedback loops. Accordingly, population increases will promote urban expansion and land use/cover changes. In turn, unregulated urban expansion, quarry evolution and LU/LC changes will continue to progress on arable lands, reducing the productive hectare per person. Agrarian abandonment will become more prevalent, while food production will decrease. Consequently, food scarcity amid a growing population will lead to resource competition. Subsequently, tensions will escalate into conflicts. As a result of deteriorating socioeconomic conditions, access to food resources, the availability of food markets, and the spread of poverty and inequality will cause food insecurity. The latter is susceptible to fuel tensions or food riots, making lands a central element in conflicts. With agrarian abandonment and land use/cover changes, the urban wildfire interface will increase and wildfires risks will grow. Climate change will exacerbate land degradation, while land degradation will influence all the above-mentioned factors. Accordingly, the interlinkages between the elements of this complex model should be further investigated. Based on what preceded, the role of land degradation as both a cause and consequence of these indicators was revealed. Therefore, the cross-cutting nature of land degradation makes it a complex field of research that requires concentrated multidisciplinary efforts.

To date, very few studies have investigated the effects of the above-mentioned indicators on land degradation in Lebanon, among other topics. In response to this gap, this research provided an updated review of events that occurred during the last nine years and their effect on national land degradation. Through this approach, several themes listed as priorities for achieving better land governance in the Arab region were included: the land-conflict nexus, the land-socioeconomic development connection, the land-natural resources relationship, the land planning regulatory framework and land urbanization, planning, and development control. The methods and indicators presented in this study may be utilized in other Arab contexts to serve their purpose and to safeguard the region's lands.

5.1 Recommendations

This study revealed several elements responsible for the deteriorating state of lands in Lebanon. Furthermore, the findings of this study unravelled the vulnerability of Lebanon to land degradation and its weakened resilience to other challenges. To remedy this situation, a solid framework linking scientists, stakeholders, decision-makers and local populations is needed. While this connection requires significant multidisciplinary efforts, it is crucial to keep in mind that lands are not inherited from our ancestors but borrowed from our children. As citizens of the Arab region, scientists are directly implicated in paving the road for land preservation and restoration. Several recommendations for Lebanon and other contexts in the Arab region are presented below. Nonetheless, the most efficient remedy would be to prevent land degradation in the first place, since the environmental and economic costs for avoiding land degradation are much less than the costs needed for land restoration. This is particularly important for countries with limited budgets and funds such as Lebanon.

A. Alignment with international land degradation strategies, conventions and frameworks

As the fight against land degradation became global, several concepts, strategies and frameworks were proposed. Undoubtedly, one the most important and internationally accepted approaches are the United Nations Convention to Combat Desertification's (UNCCD) frameworks, which Lebanon ratified. The UNCCD's Land Degradation Neutrality (LDN) concept is one of the most widely accepted, efficient and up-to-date UNCCD contributions. LDN aims to neutralize land degradation by counterbalancing land losses with land gains (Orr et al., 2017) and restoring lands by avoiding, reducing or reversing land degradation. Based on a set of indicators, LDN reveals areas of land losses, while its response strategy (avoid, reduce, reverse) aims to provide land gains to counterbalance losses and create a state of degradation neutrality. While Lebanon endorsed national voluntary LDN targets, and despite the elaboration of a National Action Plan focused on LDN and ongoing efforts, concrete national scientific approaches are still minor. A scientific analysis of LDN, its adaptation to the Lebanese context and the integration of Lebanese representative indicators were performed by Al-Sayah et al. (2019a); Al-Sayah, Abdallah, Khouri, Nedjai, and Darwish, (2019), Al-Sayah, Abdallah, Khouri, Nedjai and Darwish (2019a, 2019b) and Al-Sayah et al. (2021). These studies focused on the watershed scale to determine best practices to be scaled up across the country. The logic behind this micro to large-scale approach is that the aggregation of LDN efforts as pilo ts allows application of "what works" on larger scales (Chasek et al., 2015, 2019). However, a national-level scientific approach to LDN is recommended. The establishment of a state "land" framework, encompassing several related ministries, institutions and the private sector, is equally necessary for the long-term monitoring of land dynamics and degradation.

B. Evidence-based land use planning

Land use planning is a central element that can be integrated within each indicator. In Lebanon, serious reviews, reconsiderations and applications of land use planning legislations are needed, to ensure sustainable land use/cover changes. Land capability classification should also be integrated in land use planning since it provides evidence-based insights on the type of land use/cover that should overlay the different land capability classes. Consequently, class I and II lands should be protected from urban expansion by considering the trade-off between housing populations and conserving potent lands. A solution could be to promote vertical rather than lateral growth, which would prevent potent lands from disappearing under concrete. Given the importance of these land classes, a conversion of grass, scrub and abandoned agricultural lands to agriculture use is recommended. While the availability of fertile lands covered by grass and scrublands can be a high ecological indicator for balanced ecosystem and natural recharge, food security and environmental concerns are equally important. Therefore, the above-mentioned conversion was proposed based on land suitability (from land capability) with special attention paid for ecosystem functions. Nonetheless, land use planning and land use/cover shifts are not simple linear processes but require multi-stakeholder participation and collaboration, involving MoA, MoE, the Directorate General for Urban Planning (DGU) and the Council for Development and Reconstruction (CDR) and others.

Corrective actions (such agronomic, vegetative, structural and management measures) should be pursued on class III and IV lands. This would ensure their optimization and enhance the availability of much needed lands. Urban expansion and associated activities (quarrying) should be shifted towards these lands. Abandoned agricultural lands on these land classes are recommended to be terraced, afforested or vegetated, to reduce the soil's exposure to erosion and to prevent flammable biomass accumulation. Furthermore, this conversion will allow an organic Carbon recharge of the soil, support biodiversity and enhance land productivity.

To prevent aggravated land degradation from wildfires, hazard informed land use planning (Der Sarkissian et al., 2019) is needed. Accordingly, wildfire risk maps should be considered during land use planning, to prevent the development of biomass providing land use/cover classes in high-risk wildfire zones. Through the above-mentioned approaches, land use planning can become the lynch pin between sustainability, land resilience and natural hazards vulnerability.

C. Managing conflicts and strengthening local communities

Immediate attention should be given to the prevalent unrests and the underlying patterns of disagreement, to dissipate tensions before they escalate to conflicts. While this effort requires significant governmental intervention and the reduction of socioeconomic inequalities and injustices, the presence of large displaced populations poses additional challenges. Therefore, the needs of informal populations must be carefully considered. While awaiting their safe return to their home countries, displaced populations should be protected and attended to without compromising the national long-term land rights. Frameworks that effectively integrate displaced populations into the labour market without affecting the Lebanese working force are also encouraged. According to the recommendations of Diab, El Shaarawy, and Yousry (2020), integrated long-term strategies are needed for effective management of informal settlements. The authors further stressed the need for detailed analysis of the settlements' legality, of the effect of governmental policies on displaced populations, and of the intersection between humanitarian bodies, the government, and local host and displaced populations.

D. Enhancing preparedness and raising awareness

Raising awareness regarding land degradation is one of the most effective means to understand the process and disseminate the corresponding knowledge. However, this step may be impeded by the weak willingness of local communities to adopt practices different from their traditional ones. While local inherited knowledge should be updated to more sustainable practices, farmers and local communities are on the front lines in the fight against land degradation. Positive pilot experiences with municipalities such as Bsharre and others in the Chouf district are providing promising platforms. Mr. Luc Gnacadja, former Executive Secretary of UNCCD (2007 to 2013), emphasised this point during the International Soil Congress 2019: "Our farmers have the lead position in re-greening efforts and achieving LDN; they are the champions of change". Therefore, a successful fight against land degradation depends on transmitting scientific knowledge to local communities, as they have the highest degree of experience regarding their soils, making them the officially "unrecognized soil experts" (Engel-Di Mauro, 2014). In relation to SDG 4 (quality of education), land degradation should be integrated into higher education curricula. By increasing academic attention on the topic, awareness on land degradation can be raised in a more effective manner.

In terms food security, Lebanon should give greater support to the agricultural sector to reduce the country's dependence on imported goods and services. While this situation is also a side effect of the current financial crisis, reducing the country's dependency on imports is a priority of MoA's 2020 strategy. The establishment of land suitability maps and general planning schemes for preserving agriculture and productive lands are equally needed. Climate-resistant species should be introduced to cope with climate change impacts and ensure a viable/sustainable agriculture. To cope with wildfires, better forest management and preparedness measures (equipment, waterbodies) are needed. While the CNRS Remote Sensing Center established state-of-the-art early warning systems linking the Ministry of Interior, the Disaster Risk Management Unit, and the Lebanese Civil Defense, data issued from these systems should be integrated into proactive interventions.

5.2 Perspectives

For further research incentives the following perspectives are proposed:

- Integration of further indicators such as soil salinity and soil pollution (chemical land degradation);

- Analysis of national soil erosion patterns and rates for correlation with land degradation;

- Analysis of the economic crisis' effects on food supply chains, lifestyle changes and the trade balance;

- Integration of further natural hazards (floods, earthquakes, storms) and analysis of their dimensions;

- Integration of water resource management and resulting soil erosion processes. While soil erosion and water resource management studies in Lebanon are increasing – see Abdallah (2007), Abdallah et al. (2018), Bou Kheir et al. (2008, 2006), Darwish (2012), Al-Sayah et al. (2021), and others – and field projects are ongoing, further advances are needed. Likewise, counter-erosion measures are scarce despite the prominence of several projects. Given the role of soil erosion as the most amplified biophysical form of land degradation (Dooley et al., 2015; ELD Initiative, 2013), research efforts should concentrate on the erosion–land degradation nexus in Lebanon.

Despite the importance of these recommendations, Lebanon's capacity is becoming weaker as a result of the problems tearing the country apart. Nonetheless, several ministries are assiduously working with local authorities, international organizations, and UN bodies to find solutions. While several international bodies are financing research projects and interventions on the ground, more efforts are still needed. With the great uncertainties awaiting Lebanon's future, scientific research must intensify to help Lebanon adapt and overcome its situation. Given the position of scientists as the starting point in the communication cycle between scientists, stakeholders, decision-makers and local populations, scientific research bears substantial responsibility to provide solid and concrete evidence for decision-making. To conserve the region's source of livelihood, cultural heritage, and emblematic identity, land degradation should be placed high on Lebanese and Arab priority agendas and addressed accordingly.

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