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CLIMATE CHANGE, AGRICULTURE, & LIVELIHOODS IN LEBANON:

CONSOLIDATED LIVELIHOODS EXERCISE FOR ANALYZING RESILIENCE

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ABSTRACT

Lebanon is highly susceptible to the impact of climate change now and in the future. This is particularly true for rural areas and farming-reliant communities, where livelihoods revolve around agricultural production. To ensure targeted and efficient climate change adaptation action, WFP Lebanon commissioned AUB-IFI[1] to conduct a study to generate additional evidence on the impact of climate change and climate variability on agricultural production and rural communities.

The study adapts and applies the WFP's Consolidated Livelihood Exercise for Analyzing Resilience (CLEAR) methodology relying on extensive desk-research and stakeholder consultations at the national and sub-national levels. It maps the country according to livelihoods, enabling programming that takes people's livelihoods, and not administrative areas, as the point of departure. It provides a novel approach to understanding the negative effects of climate change on agricultural production and farming-reliant communities in Lebanon and serves to inform strategy and programme development for multiple stakeholders and facilitators of CCA at different levels of government, within relevant ministries, and for UN agencies and specialized organizations working within the field. As such, the study is an instrument for policy makers and practitioners to design and implement urgent interventions to address the negative effects of long-term, gradual climate risks on agriculture and livelihoods.

This document is an executive summary of the technical CLEAR study report. The study shows how climate change resilience levels are particularly low in the North, Akkar, and parts of the Bekaa. In addition, projections show that already vulnerable areas will be at high risk in the future but also that some currently moderately resilient areas will face problems managing the effects of climate change in the years to come. The apparent adverse effects of climate change on rural livelihoods must be addressed by various stakeholders and solutions must be tailored to respond effectively to the specific attributes of the different livelihood zones. It is recommended, that investments are made at the policy level as well as targeting communities, farmers, and vulnerable individuals directly. As such, interventions should ensure capacity-building and technology transfer programs targeting farmers, skills building for livelihood diversification, improved extension services, reduction of land degradation through climate smart agriculture, changed afforestation and reforestation policies, improved and easier access to markets for farmers, support for the utilization of smart irrigation and improved farm irrigation management, expansion of irrigation schemes, and control of groundwater access.

[1] American University of Beirut – Issam Fares Institute for Public Policy and International Affairs

INTRODUCTION

Lebanon has been enduring multiple crises since October 2019, that have had extreme environmental, economic, political, and social repercussions all over the country affecting all livelihoods. One in five Lebanese (approximately 800,000 people), and one in two Syrian refugees (approximately 750,000 people) are food insecure (WFP, 2021[2]; WFP, UNHCR & UNICEF, 2020[3]).

In specific, small-scale farmers and agricultural workers struggle under the weight of the economic crisis, and face increasing levels of poverty. Key challenges for farmers include high production costs, low value of outputs, crumbling infrastructure, and lack of liquidity due to bank control mechanisms put in place by the banking sector. The result of the economic downturn has been an overall shrinkage of the sector, which has had to move to a low input system, thus producing lower yields. This, in turn, threatens the livelihoods of the farmers who are relying mainly on agriculture to provide for themselves and their families (FAO, 2020[4]).

The agricultural sector not only suffers from the economic downturn but is also vulnerable to disasters and risks resulting from climate change, which often lead to reduced crop yields, agricultural productivity, and economic performance. The main climate change risks facing the country are gradual increases in temperature, decreases in yearly rainfall, and an increase in the occurrence of droughts and floods, all of which have already caused considerable damage to the environment and agricultural lands (MoE, 2019[5]). As a result, farmers have faced difficulties adapting to the variations in rainy and cold seasons, as the onset and duration of rainfall has become increasingly unpredictable, disturbing the seasonal calendars of crops and harming production.

Smallholder farmers are severely affected by climate change and variability, and over the coming years, they will be forced to adapt in order to sustain their production and secure year-long income generation to support food security. Climate Change Adaptation (CCA) is 'the process of adjustment to actual or expected climate and its effects' (IPCC, 2014[6]), including both a) adapting to gradual changes in average temperature, sea-level, and precipitation; and b) reducing and managing the risks associated with more frequent, severe and unpredictable extreme weather events (adapted from Turnbull et al., 2013[7]). Adaptation measures reduce the vulnerability of rural communities but can also allow them to benefit from unexpected opportunities resulting from climate change, such as growing new crops in areas previously deemed unsuitable for farming, or through the integration of climate change adaptation into national policies affecting rural communities directly.

The Government of Lebanon is attempting to tackle the impact of climate change by ensuring the sustainable management and use of natural resources with their "Responding to Climate Change" strategy. The goal is to mainstream climate change activities into agriculture. The Ministry of Agriculture also aims to further efforts towards CCA with their 2020-2025 National Agricultural Strategy (NAS), which outlines multiple activity streams to improve climate change adaptation in the future (MoA, 2020[8]).

Although the NAS highlights climate change as a component relevant for sector improvement, more implementable approaches should be developed in detail along with a timeframe for action considering the increasing and more tangible, negative climate change impacts Lebanon has seen over the past years.

[2] WFP (2021). Lebanon: m-VAM Vulnerability and Food Security Assessment.
[3] WFP, UNHCR & UNICEF (2020). Vulnerability Assessment of Syrian Refugees in Lebanon (VASyR).
[4] FAO (2020). Special Report: FAO Mission to Assess the Impact of the Financial Crisis on Agriculture in the Republic of Lebanon.
[5] MoE (2019). Linkages between Disaster Risk Reduction (DRR) and Climate Change Adaptation (CCA) in the Agriculture Sector.
[6] IPCC (2014): Climate Change 2014: Mitigation of Climate Change. Contribution of Working Group III to the Fifth Assessment Report of the Intergovernmental Panel on Climate Change. Cambridge University Press, Cambridge, United Kingdom and New York, NY, USA
[7] Turnbull, M. el al. (2013), Toward Resilience – A guide to disaster risk reduction and climate change adaptation, Warwickshire, UK.
[8] MoA (2020). Lebanon National Agriculture Strategy (NAS) 2020 – 2025.

Methodology

The CLEAR is an analytical approach developed by WFP to understand how food security and livelihoods are affected by climate risks now and in the future. The CLEAR study results are a product of solid analyses relying on extensive desk-research, field-level data collection, and stakeholder consultations.

THE CLEAR HAS THREE DISTINCT ANALYTICAL STEPS:

1 Mapping of livelihood zones: The livelihood zone maps were delineated based on similar patterns of socio-economic, locational, and environmental factors including climatic data for the past 10 years, employment data, water sources and irrigation schemes, land-use spatial data, agricultural land density, crop types, ratio of irrigated to non-irrigated agriculture, road density, population density, climatic patterns, availability of water resources, and administrative boundaries at the governorate level. [9]

2 Development of a resilience index to determine the level of resilience to climate change of communities and agricultural production respectively. Several elements have been considered:

- Poverty
- Food security
- Climate sensitivity of crops (using both the sensitivity of crops with regards to water and to chilling hours)
- Livelihood diversity

The resilience index score was produced by geometrically averaging the food security index, the poverty index and the livelihood diversity index. In turn, the developed map (figure 1) shows the climate resilience score per zone and was developed by taking the worst-case scenario (maximum values) between a climate resilience index of communities to changes in precipitation and a climate resilience index of communities to changes in temperatures (10 years).

3 Assessment of the impact of future climate risks on livelihoods, communities, and agricultural production: Three climate induced deterioration indices were developed. They respectively describe the spatial distribution of deterioration in precipitation levels, increases in average temperature levels, and decreases in chilling hours specifically provided for deciduous fruit trees. They were determined by comparing current temperature and precipitation levels with future projections at livelihood zone level.

The steps build one another, and the livelihood map produced in the first step is used as a basis for the second step, while the resilience map is used as a basis for the third step, which aims to understand the projected impact of climate change on livelihoods.

[9] The Lebanese Agricultural Research Institute (LARI) provided climatic data for the past 10 years, employment data was extracted from the latest Central Administration for Statistics (CAS) reports, water sources and irrigation schemes were provided by the MoEW and the MoA, and the land-use spatial data was acquired from National Centre for Scientific Research (CNRS).

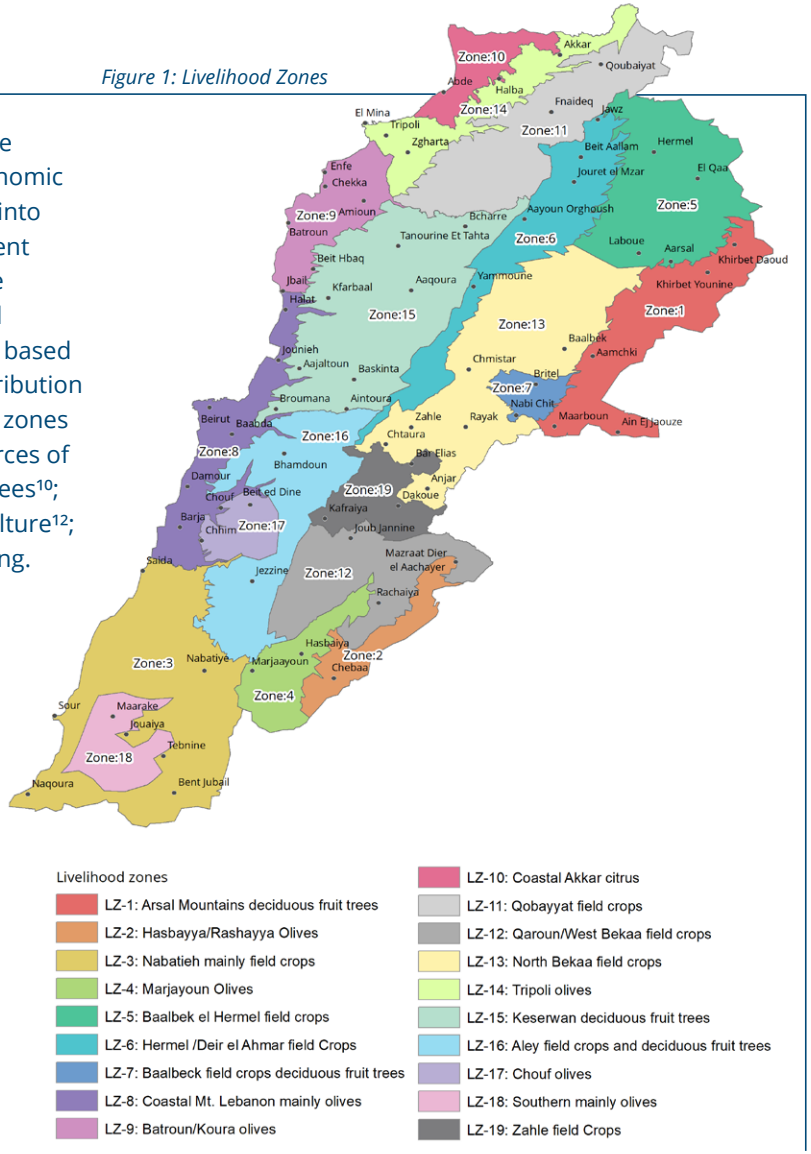
LZ-1: 17% goes to field crops, 72% to deciduous fruit trees and 9% to olive production.
LZ-2: 16% goes to deciduous fruit trees, 59% to olives and 25% to field crops.
LZ-3: 39% goes to field crops, 4% to deciduous fruit trees, 10% to bananas and 26% olive trees.
LZ-4: 58% goes to olives, 38% to field crops, 3% to deciduous fruit trees.
LZ-5: 14% goes to olives, 51% to field crops, 31% to deciduous fruit trees
LZ-6: 77% goes to field crops, 19% to deciduous fruit trees and 3% to olives
LZ-7: 49% goes to field crops, 47% to deciduous fruit trees,
LZ-8: 35% goes to olives, 18% to field crops, 20% to deciduous fruit trees, 11% farming under shelter, 8% to citrus, 6% to bananas.
LZ-9: 84% goes to olives, 5% to deciduous fruit trees, 7.6% to field crops
LZ-10: 61% goes to citrus, 13% field crops, 5% to deciduous fruit trees, 13% to olives
LZ-11: 56% goes to field crops, 11% to olives, 32% to deciduous fruit trees
LZ-12: 68% goes to field crops, 14% goes to olives, 13% to deciduous fruit trees.
LZ-13: 77% goes to field crops, 16% deciduous fruit trees, 2% to olives, 4% vineyards
LZ-14: 59% goes to olives, 12% to deciduous fruit trees, 24% to field crops.
LZ-15: 56% goes to deciduous fruit trees, 15% to olives, 26% to field crops
LZ-16: 50% to field crops, 27% goes to deciduous fruit trees, 20% to olives,
LZ-17: 70% goes to olives, 12% deciduous fruit trees, 16% to field crops
LZ-18: 42% goes to olives, 33% to field crops, 16% to citrus, 6% to bananas
LZ-19: 87% goes to field crops, 6% to deciduous fruit trees, 6% to vineyard

Key findings

LIVELIHOOD ZONE MAPPING

In the first step of the study, available land use data, climatic and socioeconomic data was used to divide the country into 19 livelihood zones, each with different characteristics. While livelihood zone profiles were developed with several attributes, the zone delineations are based primarily on the distinctive crop distribution and agro-climatic conditions. The 19 zones focus on eight main agricultural sources of livelihoods: Citrus; deciduous fruit trees[10]; field crops[11]: olives; protected agriculture[12]; banana; wine grapes; poultry breeding.

Figure 1: Livelihood Zones



[10] Apples, grapes, cherries, apricots, peaches, pears
[11] Large field crops include cereals and forages: wheat, potato, sunflower, sesame, corn, alfalfa, lupin, and corn; while small field crops also known as terraces include parsley, lettuce, eggplants, bell peppers, cucumbers, tomatoes, beans, melons, okra, and yellow pea.
[12] Protected agriculture is mostly small field crops grown in the summer in terraces and in winter they are grown in greenhouses for all year production.

RESILIENCE RANKING

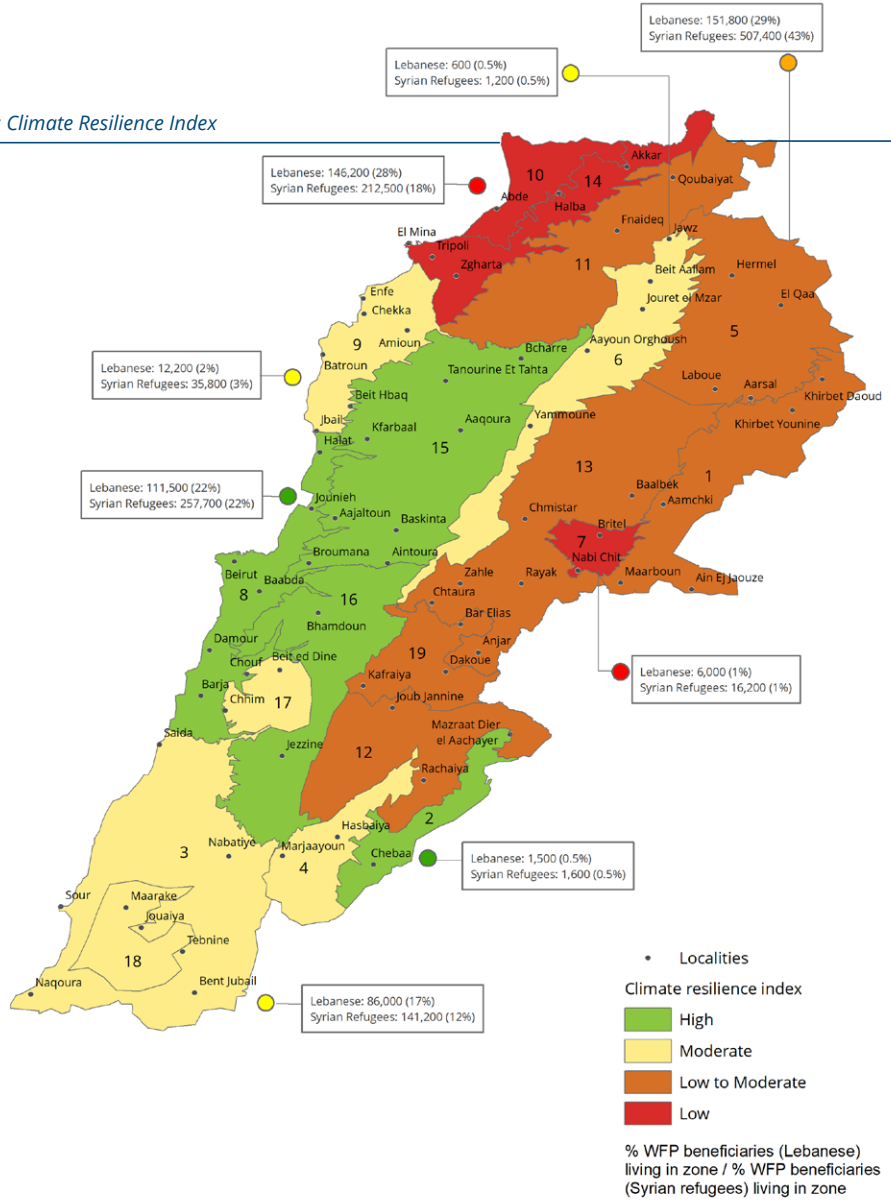
The second step assesses the resilience of communities and agricultural production to climate change. Resilience refers to the capacity to ensure that shocks and stressors do not have long-lasting adverse development consequences.

Areas with the lowest resilience index score are areas in East-Baalbeck, and Akkar. Taking into consideration socioeconomic factors and the sensitivity of crops, the resilience index for highly agricultural zones such as Zones 7, 10, and 14 is low, meaning they are sensitive to climate change and prone to further deterioration of conditions following changes in precipitation and chilling hours.

Based on the data, most of the Bekaa and Northern districts (more specifically Akkar) have a high poverty index. For climate sensitivity of crops, only Akkar has a low score, while the rest of Lebanon has low to moderate, moderate, and high climate sensitivity of crops. As for livelihood diversity, the country in its majority has a moderate to low income-diversity score meaning that most communities rely on a minimal number of sources for income.

The study's focus is on the impact of climate change on livelihoods' resilience mainly sourced by agriculture. Thus, to understand the current and future resilience of the zones to climate change, it is useful to group the 19 zones into three categories based on their agricultural land density: zones with agricultural density lower than 15%; between 16% and 49%; and 50% or more.

Figure 2: Climate Resilience Index



AGRICULTURAL LAND DENSITY ≤15%	AGRICULTURAL LAND DENSITY BETWEEN 16% AND 49%	AGRICULTURAL LAND DENSITY ≥ 50%
ZONE 1	ZONE 3	ZONE 7
ZONE 2	ZONE 4	ZONE 10
ZONE 6	ZONE 5	ZONE 14
ZONE 8	ZONE 9	ZONE 19
ZONE 15	ZONE 11	
ZONE 16	ZONE 12	
	ZONE 13	
	ZONE 17	
	ZONE 18	

Table 1. Categorizing zones according to agricultural land density

FOR ZONES WITH AN AGRICULTURAL LAND DENSITY OF MORE THAN 50 %, the analysis shows that over the past ten years, changes in chilling hours and precipitation have compromised the productivity of specific types of crops that are grown in Zones 7, 14 and 19. Zone 10 was shown to be minimally sensitive to changes in climate, with its crop distribution mainly being citrus with minor areas for the production of olives. Zones 7 and 19 were determined to be highly sensitive to climate change, with both zones focusing mainly on large field crop production (wheat, potato, sunflower, barley, corn, and sesame). Taking into consideration socioeconomic factors and the sensitivity of crops, the resilience index for highly agricultural zones such as Zones 7, 10, and 14 is low, meaning they are sensitive to climate change and prone to further deterioration of conditions following changes in precipitation and chilling hours.

FOR ZONES WITH AGRICULTURAL LAND DENSITY BELOW 15 %, climate sensitivity of crops is mostly moderate with crops grown in Zones 1 and 2 being highly sensitive to climate change. Even though these zones have minimal agricultural production, the areas are only scarcely covered by irrigation schemes, rendering them dependent on rainfall for agricultural production, which increases the sensitivity of this production and related livelihoods to any changes in precipitation brought on by climate change.

For minimally agricultural and highly urban zones such as zones 2, 8, 15, and 16, the combination of socioeconomic factors and sensitivity of crops to climate change yield a high resilience score, since the agricultural areas in urbanized regions are scant, meaning the impact of factors related to crop sensitivity to climate changes become relatively small compared to the socioeconomic factors. For Zones 1 and 6, where the limited agricultural areas are comprised of deciduous fruit trees and field crops (wheat, potato, sunflower, barley, corn, and sesame), the resilience to climate change is moderate to low. This is because deciduous trees and field crops are sensitive to changes in chilling hours and precipitation, respectively.

THE ZONES WITH AGRICULTURE LAND DENSITY BETWEEN 16-49% are highly to moderately sensitive to climate change. Zone 11, heavily reliant on deciduous fruit tree production, has been moderately sensitive to changes in chilling hours over the past ten years.[13] Zones 2, 9, 17 and 18, where olives are the main type of crop cultivated, are vulnerable to changes in precipitation since olives are mainly rainfed and any reduction in rainfall will automatically lead to a reduction in crop yield and at times may affect the quality of the fruit and by-products (olives and olive oil). The impact of chilling hours and precipitation reduction therefore results in loss of income to farmers negatively affecting livelihoods.

For zones 3, 4, 5, 9, 11, 12, 13, 17, and 18, the combination of socioeconomic factors and sensitivity of crops to climate change yield a low to moderate, or moderate resilience score. Zones 11, 12 and 13, which currently have low to moderate resilience and where agriculture is mainly focused on large field crops along with some deciduous fruit and olive production, are prone to decrease in resilience in the future. Here again, the reliance of Zones 11 and 12 on rainfall for irrigation jeopardizes the consistency in expected crop yield which results in heightened vulnerability of associated communities. Even Zone 13, which is mostly covered by irrigation schemes according to the MoEW, relies on rainfall irrigation for olive production.

[13] It is important to note here that some deciduous fruit trees (such as apples) have specific temperature requirements (a certain number of chilling hours) for their fruits to set. If these requirements (e.g. length of continuous hours below a certain temperature) are not met, then fruit setting could be aborted resulting in low yields. Thus, the areas that are dominated by such fruit trees are especially vulnerable to changes in chilling hours.

The analysis achieved thus far has allowed us to understand the level of climate resilience in the different livelihood zones. The third step aims to better understand how climate change and climate risks affect livelihoods in the coming decades. The final step therefore develops a climate projection model that can predict changes in climate and the effect on agricultural production and communities in 2050. Utilizing the IPCC prediction model for 2050 and the Third National Communication report, values are calculated for changes in precipitation, temperature, and chilling hours. Projected impact is analyzed at two levels:

1) the impact on agricultural production

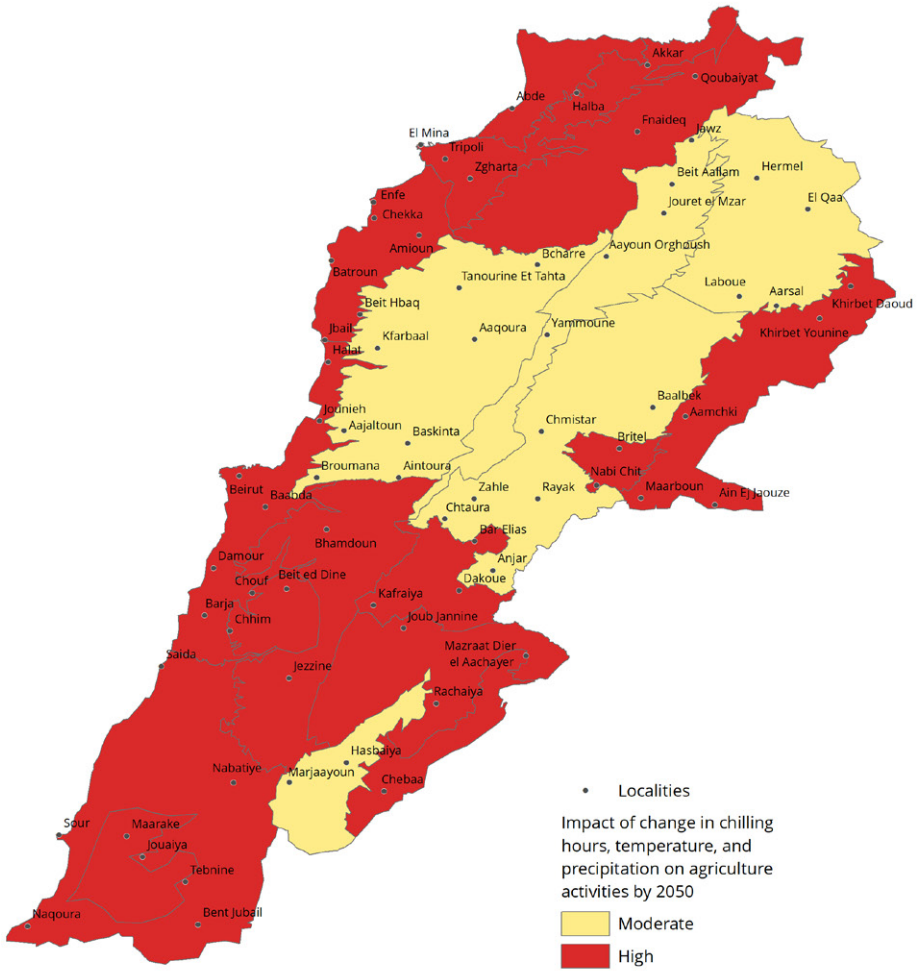
2) the impact on communities

Future Impact on Agricultural Production

The impact on agricultural activities was assessed by combining data on 1) the changes in chilling hours and 2) the impact of the decrease in precipitation on agricultural activities.

IN ZONES WITH AN AGRICULTURAL LAND DENSITY ABOVE 50 %, the climate projections show that changes in chilling hours, temperature, and precipitation by 2050 will have a high impact on agriculture which would directly impact sources of livelihood in Zones 7, 10, 14, and 19 since these zones have some of the highest percentages in the country of the labour force working in agriculture according to the FAO/MoA census conducted in 2010.[14]

Figure 3: Impact of changes in chilling hours, temperature, and precipitation on agricultural activities by 2050



IN ZONES WITH AN AGRICULTURAL LAND DENSITY BELOW 15 %, changes in chilling hours, temperature, and precipitation by 2050 will have a high impact on agriculture production in Zones 1, 2, 8, and 16 and a moderate impact on Zones 6 and 15. The impact will directly affect people working in agriculture in these zones, namely in Zones 15 and 6 where, on average, between 37 and 50% of people work in agriculture, while in Zones 2, 8, and 16 on average less than 37% of work in agriculture

ZONES WITH AN AGRICULTURAL LAND DENSITY BETWEEN 16-49 % will have even worse conditions in the future. Zones that are currently low to moderately climate sensitive such as Zones 12 (low) and 9 (low-to-moderate), will be further impacted by changes in chilling hours, temperature, and precipitation. Zone 13, which includes the Bekaa region where more than 53 % of the labor force works in agriculture (RICCAR, 2019), will be moderately impacted, mainly because the zone is fed by irrigation schemes, which would mitigate the impact of precipitation decreases.

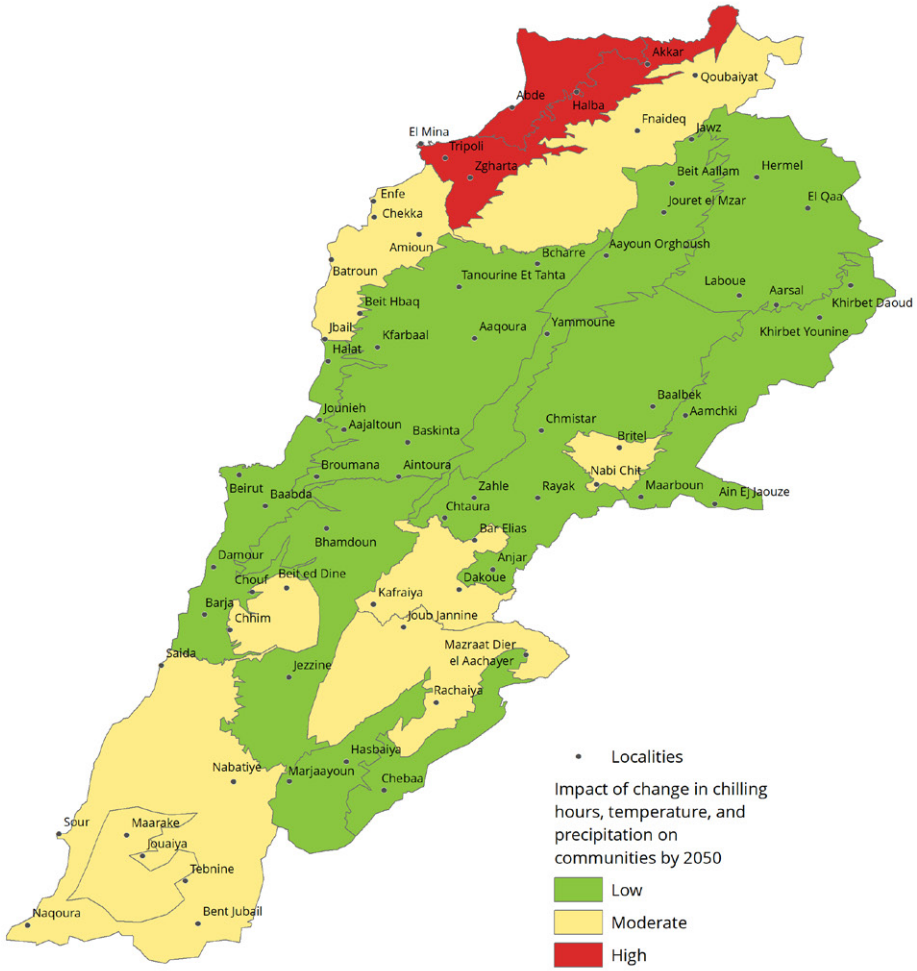
[14] More than 70% of the labour force in Zones 14 and 19 communities relies on agriculture, while 53-61% of communities in Zone 7, and between 62-71% of communities in Zone 10 rely on agriculture.

Figure 4: Impact of changes in chilling hours, temperature, precipitation on communities by 2050

Future Impact on Communities

The impact on communities was assessed by combining data on 1) the impact of chilling hours deterioration on communities and 2) the impact of climate induced deterioration (water demand vs. supply) on communities.[15] Assuming that there is no change nor any interventions to ameliorate the socioeconomic conditions in the country, Figure 3 shows the combined impact of predicted changes in climate by 2050 and the identified resilience factors (poverty, food, security, and livelihood diversity. It is important to point out that the socio-economic data was collected in 2019, prior to the COVID-19 pandemic, the Beirut Blast, and economic crisis that Lebanon has been going through since early 2020. As such, the impact on communities is likely to be much higher than indicated by this study.

ZONES WITH AN AGRICULTURAL LAND DENSITY OF ABOVE 50 %, ZONES 7, 10, 14, AND 19, will be highly impacted by climate change by 2050. When taking into consideration factors beyond climate change impact by 2050, such as sensitivity of crops, zones 7 and 19 would require more urgent interventions. Zones 10 and 14 currently have high poverty index along with a food security index that is low for Zone 10 and moderate for Zone 14 as well as a low livelihood diversity index. The socioeconomic indicators currently show that these two zones, which are already struggling on a number of parameters, are likely to face even worse conditions by 2050, especially since the negative impact of changes in chilling hours, temperatures, and precipitation on agricultural activities will be high. Indeed, when combining socioeconomic and climatic data with projected scenarios, it becomes apparent that Zones 10 and 14 are highly vulnerable. Zone 19 has a high food security index and a moderate poverty index, but a high climate sensitivity score, resulting in overall high impact (all factors combined) for Zone 19. The same applies for Zone 7.



ZONES WITH AN AGRICULTURAL LAND DENSITY BELOW 15 % are relying minimally on agriculture and will be least impacted by climate change. Because these areas are more urbanized, the effect of the socioeconomic indicator scores dominated those of agricultural scores such that changes in chilling hours, temperature, and precipitation showed minimal effect, especially at the community level.

ZONES WITH AN AGRICULTURAL LAND DENSITY BETWEEN 16-49 % the climatic projections show that zones 9, and 18, which are mostly focused on olive and large field crop production, will have low resilience by 2050, affecting the main source of income for the labour force working in agriculture.

[15] The climate resilience index of communities to decreases in chilling hours and precipitation was determined by geometrically averaging: 1) Food security index, 2) Poverty index, 3) Livelihood diversity index, 4) Climate sensitivity index of crops to decreases in chilling hours, and climate sensitivity index of crops to water

Climate Change Impact on Agricultural Production & Families in Bar Elias

Livelihood zone 19 scores low on the climate change resilience index. There is a high sensitivity of crops in the zone, high projected impact of climate change on agriculture by 2050, and a high percentage of labor working in the agricultural sector. The agricultural land density in Bar Elias is 81.6 %. The main, and often only source of income in and around the village is agricultural production. The case study interviewed 22 farmers in the area to understand how climate change impacts their lives and livelihoods. All respondents were male with an average age of 54 years.

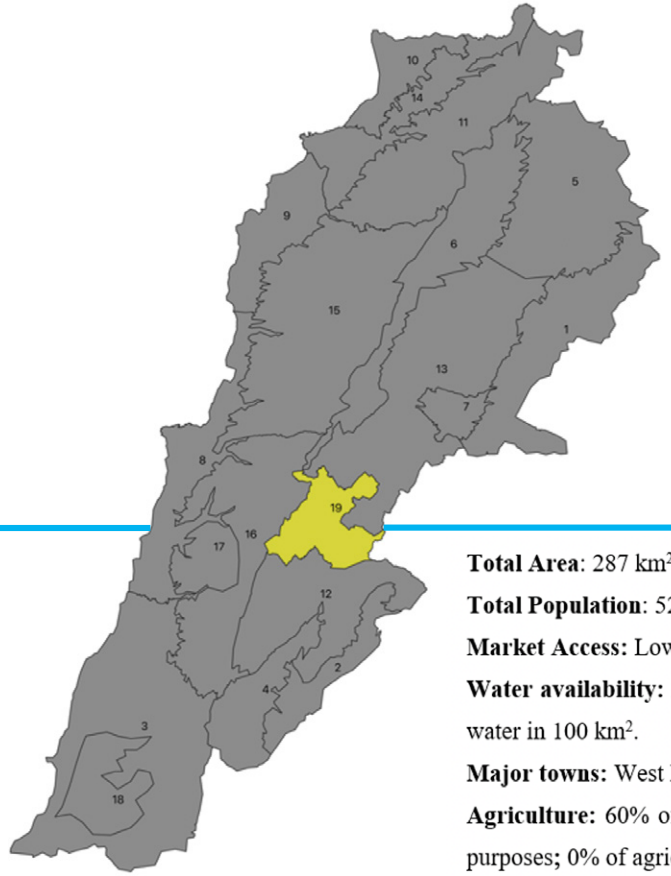
OF THE 22 SURVEYED FARMERS IN BAR ELIAS:

16
farmers have agricultural production as their only source of income and 15 of these provide for 3-6 dependents

20
farmers have witnessed severe crop loss over the past ten years. Climate change plays a large role in crop sensitivity.

All farmers
have witnessed an increase in temperature and a decrease in rainfall over the past ten years.

18
farmers have witnessed a reduction in water availability for their agricultural production.



Total Area: 287 km^2
Total Population: 52,450
Market Access: Low
Water availability: Approximately 0.7 sources of water in 100 km^2.
Major towns: West Bekaa, Zahle
Agriculture: 60% of land is used for agricultural purposes; 0% of agricultural land is irrigated

Precipitation:
10Yr Precipitation average: 769 mm/year.
2019 Precipitation: 872 mm/year.

Crops Distribution:
87% field crops, 6% deciduous fruit trees, 6% vineyard

SUMMARY

Building on WFP's strategic efforts to sustainably improve household food security and community resilience to economic and climatic shocks and stresses for vulnerable Lebanese and displaced populations, the study generates an evidence base on the impact of climate change in Lebanon. It provides a novel approach to understanding and acting on the negative effects of climate change on agricultural production and farming-reliant communities. The division of the country into livelihood zones provides practitioners and policy makers with an actionable reference for analysis of climate change-related problems now and in the future.

The study was conducted based on data from 2019. For future use, zoning can be updated with new data that reflects the rapidly changing socioeconomic conditions, as resilience scores identified in all zones are likely to change. Poverty rates alone have increased drastically in 2021, affecting food security and household resilience. Available land use data, climatic and socioeconomic data allowed for the division of Lebanon into 19 Livelihood Zones, each with different characteristics and current climate change resilience levels. Zones relying heavily on agriculture will be negatively impacted by climate change manifested in an anticipated reduction in agricultural productivity. The effect trickles over into other zones where agricultural land density is less than 50%. More specifically, coastal areas, where agriculture is mainly focused on olive and citrus production, will be heavily impacted by changes in precipitation and water supply.

At higher elevations, where agricultural production consists mostly of deciduous fruit trees, changes in chilling hours and temperature will negatively affect deciduous fruit tree productivity. In the Bekaa Valley, one of the most important agricultural areas in Lebanon, zones relying on irrigation schemes will be negatively impacted by climate change through increasing groundwater stress levels and a depletion of water sources.

All of these effects will have negative bearings on the livelihoods of the various communities inhabiting these zones. Given the projected impacts on agricultural production in zones with agricultural land density above 50%, and around 70% of the labor force employed in the agricultural sector, at least two dimensions of food security will be negatively affected: food availability and the stability of food supply.

RECOMMENDATIONS

The apparent adverse effects of climate change on rural livelihoods must be addressed by various stakeholders and solutions must be tailored to respond effectively to the specific attributes of the different livelihood zones.

At the individual and community levels, increased resilience of communities where agriculture is a key source of income may be achieved by applying a range of climate change adaptation measures. These include:

GOVERNANCE AND POLICY

• Policy and strategy developments must be coordinated with various ministries and governmental and nongovernmental organizations to produce holistic plans that account for the requirements of all associated sectors thereby improving productivity and sustainability of the plans. CCA must be implemented through the complimentary policies of a number of sectors such as agriculture, water resources, health, land use, environment, infrastructure, finance, and planning among others.

• Capacity-building and technology transfer programs need to be initiated targeting all farmers (both small and large-scale). This would involve helping farmers have access and adopt new cultural practices that would mitigate the negative impact of climate change.

• Financial support for the education of farmers on the use of smart agriculture using remote sensing information for various crop activities such as pest infestation, soil moisture, irrigation practices, and precision farming. Small scale and large-scale loans and grants must be made available to farmers to purchase required material and equipment to support the sustainability of farm operations.

• Extension services must have personnel available that are properly equipped and trained to relay to farmers the requirements of markets (local and foreign) and support them in meeting them.

• Reduction of land degradation through climate smart agriculture for example conservation agriculture and with a focus on growing crops that best fit the changing climate.

• Changing afforestation and reforestation policies to encourage initiatives focused on forest management through recovery and reforestation. All of these would help Lebanon in reaching its Nationally Determined Contributions (NDC) goals for the reduction of greenhouse gas (GHS) emissions.

COMMUNITY RESILIENCE THROUGH CCA

In many zones, livelihood diversity is minimal, and communities rely heavily on agriculture.

• Governmental organizations and NGOs must support diversification of income streams. Households that have a broad stream of incomes from farm work (e.g. cultivation), off-farm work (e.g. agro-processing), and non-farm work (e.g. construction, education) would be better equipped to mitigate the impact of floods, droughts, infestations, and other environmental shocks. Household income source diversification must also be encouraged through the empowering of several members of the same household, especially women, to become income generators through work in different sectors such as services, manufacturing, and education. Thus, awareness raising, information campaigns, educational sessions, and skills-building initiatives should be rolled out to promote other forms of (off-farm or non-farm) employment opportunities.

• In addition, households must be supported financially and in terms of capacity to be able make shifts to other sectors. This support is crucial, as shifts are a necessity but complicated and risky for households in the current context and with Lebanon's severe structural problems, including high unemployment levels across age groups and geographical locations.

• Improved and easier access to markets is a factor that contributes positively to the resilience of farming communities. In this study, roadway networks were

used as a proxy to measure the ease of access to markets. Road density was used as an attribute to map zones and identify vulnerable areas. The road density percentage was low in the more vulnerable zones, hence indicating minimal access to marketplaces. Thus, improved marketplaces, agriculture roads, appropriate post-harvest storage facilities, cooling facilities and adequate transportation are critical elements to ensure adequate and efficient access to markets with minimal loss and costs for farmers.

• Additionally, strengthened communication and networking between various farmer organizations on the negotiation, organizational capacities, and business skill levels (e.g. cooperatives, informal farmers groups) can contribute positively to improving smallholders' terms of trading with wholesalers and distributors.

MEASURES MUST BE TAKEN TO COUNTER THE IMPACT OF INCREASING WATER SCARCITY AND RISING TEMPERATURE

• Current irrigation schemes must be rehabilitated to reduce water waste and ensure that water allocation is based on actual crop demand. Water storage capacity must be improved to ensure water availability during the dry season.

• Support the utilization of smart irrigation and implementation of improved farm irrigation management. Within this approach the potential utilization of the concepts of deficit or supplemental irrigation must be explored.

• Irrigation schemes do not currently cover all agricultural lands in Lebanon. Expansion of such schemes is thus recommended so that coastal areas and livelihood zones that are not currently covered may be served. In this expansion, as well as for the existing irrigation systems, the development of alternate sources of water must be explored. Continued and improved rainwater harvesting techniques must be further developed and applied.

• Access to groundwater must be controlled as many aquifers are already stressed due to over exploitation and/or pollution. This must be accompanied with the availing of alternate water sources to farmers.

• Changes in temperature and precipitation patterns show a significant effect on the production of wheat, potatoes, and other large field crops cultivated mainly in the Bekaa area. Higher spring temperatures and higher evapotranspiration (ET) will decrease soil moisture and increase aridity that will reduce yields by 2050. Hence, farmers must be encouraged to implement the following (amongst other measures):

• Adopt conservation agriculture

• Change planting dates and cropping patterns according to projected variations and changes in temperature and precipitation

• Adopt drought tolerant crop types and varieties

• Breed new native livestock that are acclimated to warmer conditions

Of the above measures, some may be prioritized in the short-term including the majority of governance elements and activities related to changing of cropping patterns and planting dates, water harvesting measures, conservation agriculture, control of access to groundwater, and awareness campaigns.

In the medium term, financial support for the introduction of smart agriculture elements can be explored; along with training and education of farmers and communities; improvement of the current irrigation schemes; and utilization of treated sewage effluent.

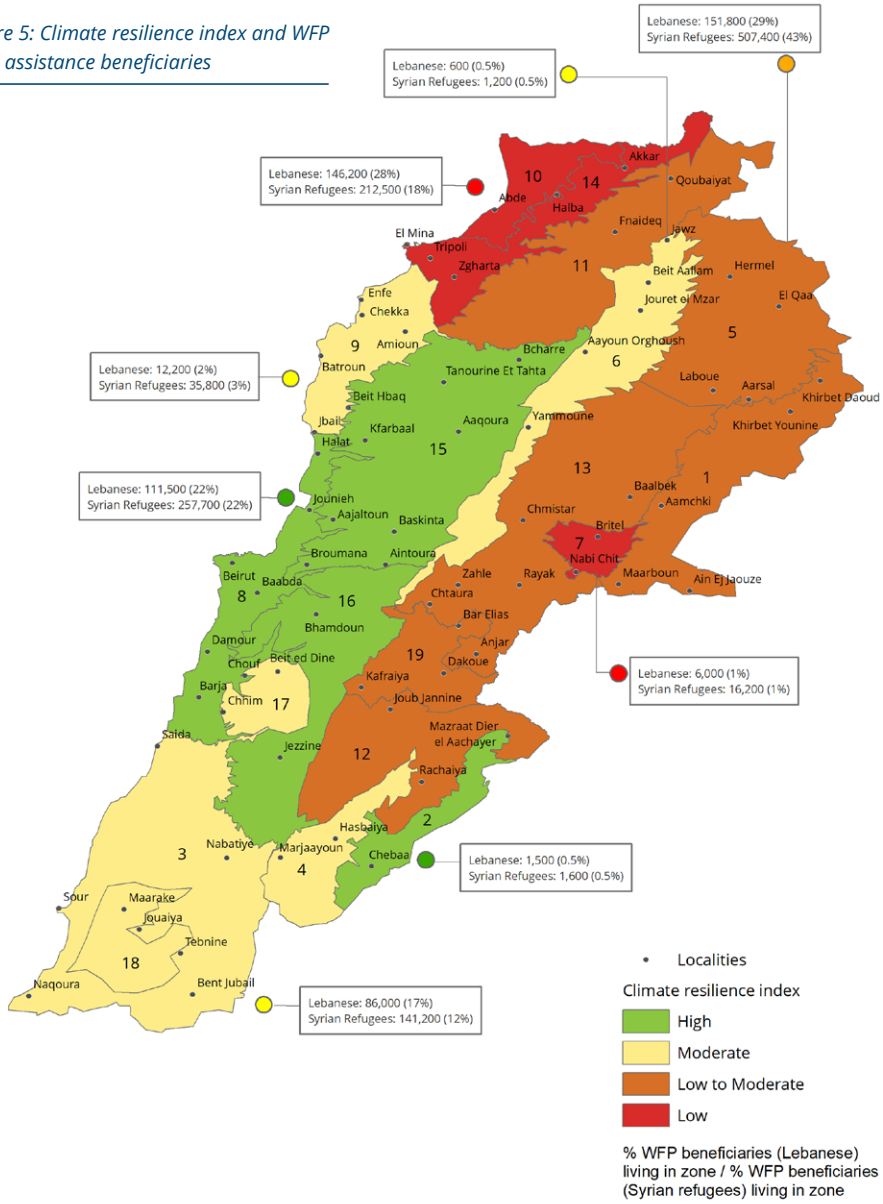
Longer-term measures include expanding the current formal irrigation networks; increasing water storage capacities; improving road networks, introducing new native livestock breeds; and the systematic and wide-scaled deployment of smart irrigation systems.

RECOMMENDATIONS AS BASED ON ZONE CHARACTERISTICS

The CLEAR report prioritizes interventions at the individual zone level, rather than prioritizing the zones. However, to further inform WFP and partners' area-based programming, the following section adds a dimension to the maps developed, by considering the concentration of WFP beneficiaries. The more elaborate prioritization of interventions within individual zones over the short, medium, and long terms can be found in the full CLEAR report (available upon request).

Figure 5 overlays the climate change resilience ranking of the zones with data on the concentration of people in need in the different areas.[16] The percentage of people assisted by WFP is an indicator of the vulnerability level in a certain area. WFP assists a high number of Lebanese people and Syrian refugees in the North and Akkar and particularly in the low and low-to-moderate resilience zones. There is also a high percentage of WFP beneficiaries in the high-resilience zones to the West reflecting to a great extent the assistance provided to the poorest and most vulnerable individuals in the Beirut and Mount Lebanon areas.

Figure 5: Climate resilience index and WFP food assistance beneficiaries



Interventions are much needed in the livelihood zones in the North, Akkar, and the Bekaa, and to some extent and for certain interventions in the South and Nabatiyeh. As this study focuses primarily on the climate change resilience of agricultural production and farming-dependent livelihoods, the high-resilience, minimally agricultural, and highly urban zones of Beirut and Mount Lebanon (zones 2, 8, 15 and 16) are of lower priority for the recommended CCA interventions. However, despite having agricultural land density of below 15 %, some of these zones, such as zone 16, does require CCA interventions as this zone is set to face high impact of climate change by 2050 and has relatively high percentage of the population that works in the agricultural sector.

[16] Note that the figure 5 indicates accumulated beneficiary numbers per area and colour coding, and not per zone. The zone-specific beneficiary numbers are provided in Table 2.

THE ZONES HAVE THE FOLLOWING KEY CHARACTERISTICS

Table 2: Zone characteristics

Zones recommended for immediate interventions

Zone	Percentage agriculture land density	Current sensitivity of crops	Climate resilience score	Projected climate change impact on agriculture	Labor percentage in agriculture	WFP beneficiaries (Lebanese)	WFP beneficiaries (Syrian refugees)
1	<15%	High	Low to moderate	High	53-61%	550	147
2	<15%	High	High	High	<37%	1.500	1.600
3	16-49%	Low to Moderate	Moderate	High	53-61%	62.834	99.265
4	16-49%	Moderate	Moderate	Moderate	38-52%	4.398	10.232
5	16-49%	Low to Moderate	Low to moderate	Moderate	53-61%	33.157	71.456
6	<15%	Moderate	Moderate	Moderate	53-61%	600	1.200
7	>50%	High	Low	High	53-61%	6.000	16.200
8	<15%	Moderate	High	High	<37%	78.316	209.705
9	16-49%	Moderate	Moderate	High	38-52%	12.000	35.800
10	>50%	Low	Low	High	62-72%	62.688	95.030
11	16-49%	Moderate	Low to moderate	High	62-72%	49.412	59.195
12	16-49%	High	Low to moderate	High	38-52%	9.598	34.953
13	16-49%	Low to Moderate	Low to moderate	Moderate	53-61%	45.982	215.873
14	>50%	Moderate	Low	High	>73%	83.512	117.470
15	<15%	Moderate	High	Moderate	53-61%	14.694	17.823
16	<15%	Moderate	High	High	38-52%	18.490	30.172
17	16-49%	Moderate	Moderate	High	<37%	4.830	14.315
18	16-49%	High	Moderate	High	53-61%	13.938	17.388
19	>50%	High	Low to moderate	High	>73%	13.101	125.776

When factoring in the zone characteristics and including the layer of WFP vulnerable beneficiaries, the following zones are highlighted as recommended focus areas for interventions in the immediate future.

Considering that more than 73% of the labour force in Zones 14 and 19 works in agriculture, these zones would be considered high priority. Zones 10 and 14 currently have acceptably low climate sensitivity of crops. However, projection data indicate that the impact on the agricultural sector will be high by 2050 directly impacting agriculture as a source of livelihood for a large percentage of the community, especially in Zone 14. Therefore, interventions are required, particularly at the community resilience level. The three zones all have a high concentration of WFP beneficiaries. Together they account for 31 % of Lebanese WFP beneficiaries and 29 % of Syrian refugee WFP beneficiaries.

The conditions in Zones 7 and 19, which are already highly sensitive to climate change will worsen by 2050. Interventions at the governance and community resilience levels would be required to lessen the impact of future climate change and ameliorate the current sensitivity of the agricultural sector. For instance, current irrigation schemes must be rehabilitated to reduce water waste and be operated to ensure that water allocation is based on actual crop demand. Zone 7 covers only a small area, but the number of WFP beneficiaries is high relative to the size of the zone.

Zones 3, 11 and 18 are facing high impact of climate change by 2050 as well as a large percentage of the community working in the agricultural sector, and a relatively high number of WFP vulnerable beneficiaries (24 % Lebanese and 15 % Syrian refugees) in the three zones combined. Interventions should include support for the utilization of smart irrigation and implementation of improved farm irrigation management. In addition, adopting drought tolerant crop variations would have a positive effect, as would promoting the access to markets for farmers at the community level.

Note that although zone 13 has a high number of WFP beneficiaries (9 % Lebanese and 18 % Syrian refugees) indicating lower food security levels, it has a low to moderate sensitivity of crops and a moderate projected climate change impact on agriculture. This is because the zone is well covered by irrigation schemes, which would mitigate the impact of precipitation decreases. In this zone as well as in zone 5, a focus on livelihood diversification would be needed to support individuals to increase their options for generating income beyond the agriculture sector.

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