Al Murunah technical baseline assessment for

Resilient Nature-based Water Solutions (RNBWS) in Ras Baalbeck and Qaa, Lebanon

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Executive summary

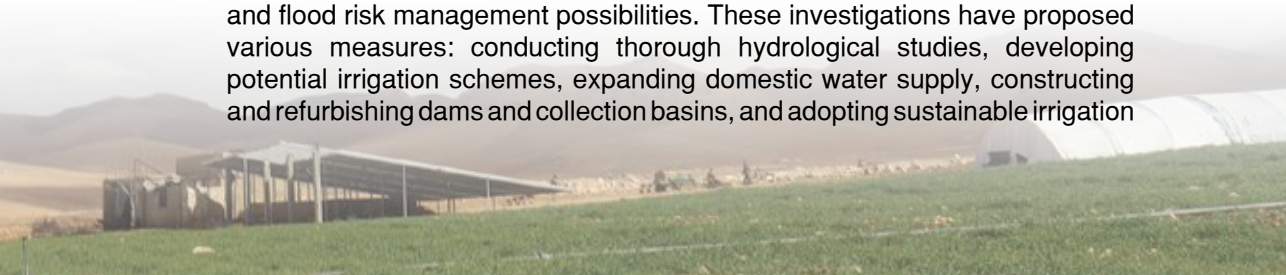
The Middle East and North Africa (MENA) region is currently facing significant water scarcity issues, further exacerbated by unsustainable agricultural practices that have led to the depletion of water resources. To address this critical situation, the UK government has initiated the “Al Murunah” project, focusing on enhancing water security within the MENA region. This project emphasizes the integration of Nature-based Solutions for Water (NBSW) and Agricultural Water Management (AWM). The primary targets of the project are Jordan, Lebanon, the Occupied Palestinian Territories, and Egypt. Its main objective is to bolster national capacities in these countries for the implementation of integrated NBSW/AWM strategies. These strategies encompass various interventions, such as watershed management, upgrading irrigation and drainage systems, and the adoption of water-harvesting techniques.

In Lebanon specifically, the Ministry of Energy and Water (MEW) and the Ministry of Agriculture (MoA) have formulated national strategies. These strategies are aimed at effectively managing water resources and enhancing agricultural productivity, aligning with the United Nations’ Sustainable Development Goals (SDGs). Key components of these strategies include the development of an Integrated Hydrological Information System, the establishment of disaster management plans, and the enhancement of service coverage in critical areas such as potable water supply, wastewater collection, and irrigation water systems. These initiatives are part of Lebanon’s concerted effort to mitigate the challenges posed by water scarcity and to ensure sustainable agricultural and water resource management.

Core findings related to the hydrological assessment of the study area

In Northeastern Lebanon, areas including Ras Baalbeck, Fekha, and Qaa are challenged by their varied terrain, featuring slopes and rugged mountains. Climate change exacerbates these difficulties through increased temperatures, decreased rainfall, and heightened drought risks. The region is noted for its rich biodiversity and soil composition that includes Leptosols, Regosols, and Calcisols. Land use predominantly consists of natural landscapes, agricultural terraces, and fruit orchards, with a rural setting prone to flooding. The water resources vital for agriculture are challenged by inefficient irrigation and the potential overuse of groundwater. Unchecked pollution also poses a threat to water quality.

Prior studies in this region have examined its hydrology, water resources, and flood risk management possibilities. These investigations have proposed various measures: conducting thorough hydrological studies, developing potential irrigation schemes, expanding domestic water supply, constructing and refurbishing dams and collection basins, and adopting sustainable irrigation



methods through comprehensive master planning. Flood assessments in the area have revealed significant gaps that must be addressed to effectively implement Nature-based Solutions (NbS) and Agricultural Water Management (AWM) strategies for flood risk management. These gaps include the need for detailed flood hazard and risk assessments and the insufficiency of existing NbS and AWM practices, which are deteriorating due to inadequate maintenance and recurrent flooding. Erosion of retention ponds and earth ridges has compromised their effectiveness in flood mitigation. Additionally, the placement of flood protection structures requires reevaluation, along with the simulation of various flood scenarios and the creation of flood inundation maps.

Based on these findings, several recommendations have been proposed for specific interventions:

- Rehabilitate retention ponds and other structures, informed by flood risk assessments.
- Schedule regular maintenance of retention ponds to minimize future repair costs and flood risks.
- Routinely clear the main village stream of stones and dust.
- Manage water in retention ponds post-storms to prevent overflow.
- Conduct field inspections and maintenance of basins and sewers following heavy torrents.
- Preserve vegetation cover and initiate afforestation in basins to reduce erosion.
- Restore natural floodplains to enhance the river system's capacity for floodwater storage.
- Create riparian buffer zones for stabilizing streambanks and additional floodwater storage.
- Develop a rainfall monitoring and early warning system with automated weather stations.
- Implement and activate a comprehensive storm action plan.
- Consider removing bridges in narrow stream sections.

Core findings related to the socio-economic assessment of the study area

The socio-economic study conducted in the regions of Ras Ba'albek, Qaa, and Fekha, predominantly rural areas, places a significant focus on agriculture and water resources. The findings indicate that the combined impact of economic challenges, labor market disruptions due to currency depreciation, soaring inflation, and the COVID-19 pandemic have exacerbated the vulnerability and informal employment among these already distressed communities. Agriculture is a key sector in this region, yet farmers face numerous obstacles. They require assistance to transition away from certain traditional practices and need financial support to sustain their agricultural activities. This need is

amplified by the absence of public electricity for water pumping and the high costs of fuel, seeds, and fertilizers.

In recent years, the region has experienced several floods, particularly in Ras Ba'albek and Qaa. These floods have had a detrimental impact on agricultural fields and villages, causing significant soil damage. The increasing risk of flooding is further compounded by the reliance on temporary and often inadequate solutions. Social tensions are also escalating in these communities, particularly between the host Lebanese population and the Syrian refugee community. This is largely due to growing competition for access to water and livelihood opportunities.

The study also highlights gender-specific challenges in the region. Women are adversely affected by labor laws that restrict their rights to work in agriculture. Additionally, the unemployment rate in the Ba'albek Hermel governorate, which includes these areas, is one of the highest in Lebanon. Women, in particular, face greater discrimination, with very limited job opportunities available to them. This situation underscores the need for targeted interventions to address these multifaceted socio-economic challenges, particularly in terms of employment, agriculture, and flood risk management, to improve the overall well-being and resilience of these communities.

Core findings related to legal and policy assessment of the study area

Below is a SWOT analysis for the pilot project in Lebanon. The SWOT analysis of North Bekaa reveals a multifaceted agricultural and environmental landscape. The region's diverse topography provides unique opportunities for different agricultural methods. Natural water drainage facilitated by the network of wadis draining into the Assi and Bekaa Valleys enhances the agricultural potential. Socio-economically, North Bekaa has a rich history in agriculture, offering a robust foundation for economic development. Places like Ras Ba'albek are not only agriculturally rich but also possess historical significance, attracting tourists and contributing to the local economy. However, some weaknesses pose challenges to the region. The current irrigation methods, such as drip irrigation, are not uniformly applied and lack efficient regulatory mechanisms, leading to significant water loss. The severe economic crisis in Lebanon exacerbates social tensions between host communities and refugees, threatening social cohesion.

The analysis also identifies opportunities that could potentially strengthen the region's resilience. There is scope for expanding terraced lands for fruit tree production and implementing reforestation practices for soil and land conservation. The adoption of advanced agricultural technologies and water harvesting practices could significantly address water scarcity and enhance food security. Yet, these opportunities are threatened by several factors,

including climate change, which is likely to affect rainfall patterns, temperature, water availability, and consequently, agricultural productivity. The economic sector faces substantial losses due to climate-related disasters. Moreover, environmental degradation, heightened water demand projected for 2040, and uncontrolled pollution from various sources threaten water quality and ecosystem health, posing serious challenges that need to be addressed through strategic planning and sustainable practices.

Figure 1: SWOT analysis for Ras Baalbeck and Qaa areas. (Source: Prepared by the report authors)

Synthesis – going forward

The baseline assessment serves as a crucial scientific tool supporting the decision-making process in the participatory planning for the Resilient Nature-based Water Solutions (RNBWS) interventions. It plays an integral role in the comprehensive implementation of these interventions by identifying the specific opportunities and challenges unique to each context. The primary aim of this assessment is to establish a solid foundation for the implementation of pilot projects, considering the specific conditions of each site and facilitating the involvement of stakeholders throughout the project.

A community-based planning approach has demonstrated significant potential for achieving consensus among various stakeholders. This approach

has underscored the importance of soft components, such as dialogue and holistic planning, which are as critical as the physical (hard) components of the project.

In Lebanon, this assessment specifically focuses on the state of water resources and agriculture in the municipalities of Qaa, Ras Ba'albek, and Fekha, given their hydrological interconnectivity. The study involves gathering and conducting preliminary analysis of data related to water resources, agriculture, and socio-economic factors. Technically, this assessment is vital in identifying potential risks to water resources, particularly in the context of flood risks, and in developing appropriate management strategies. It also enhances the understanding of the dynamics of water resources in the area and the impact of human activities on the environment. This comprehensive assessment is, therefore, essential in guiding the effective and sustainable implementation of RNBWS interventions in these communities.

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The completion of this publication would not have been possible without the support received from other organisations and individuals, particularly Antoine Allam and Liliane Nasrallah. Sincere thanks is extended to all concerned. Our deepest appreciation goes out to Ministry of Energy and Water (MoEW) for their contributions and support in producing this publication.

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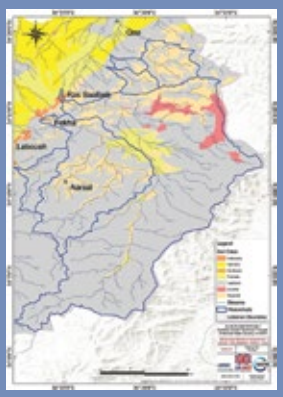
List of acronyms

AUB	American University of Beirut
AWM	Agricultural Water Management
CAS	Central Administration of Statistics
CMIP6	Coupled Model Intercomparison Project Phase 6
FGD	Focus Group Discussions
GDP	Gross Domestic Product
IHIS	Integrated hydrological information system
IUCN	International Union for Conservation of Nature
IWMI	International Water Management Institute
KII	Key Informant Interviews
LMS	Lebanese Meteorological Service
LULC	Land Use/Land Cover
LWQS	Lebanon Water Quality Survey
MCM	Million Cubic Meter
MENA	Middle East and North Africa
MEW	Ministry of Energy and Water
MoA	Ministry of Agriculture
MoE	Ministry of Environment
NAS	National agriculture strategy
NbS	Nature-based Solutions
NBSW	Nature-based Solutions for Water
NDU	Notre Dame University
NEET	Not engaged in employment, education, or training
NGOs	Non-governmental Organizations
NWSS	National Water Supply Strategy
RCM	Regional Climate Model
RNBWS	Resilient Nature-based Water Solutions
SCADA	supervisory control and data acquisition
SDGs	Sustainable Development Goals
SWOT	Strengths, Weaknesses, Opportunities, and Threats
UNFCCC	United Nations Framework Convention on Climate Change
UNHCR	United Nations High Commissioner for Refugees
UNIDO	United Nations Industrial Development Organization


Oms
Ras Baalbek
Fekha
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Introduction

Introduction

The Middle East and North Africa (MENA) region is characterized by some of the highest levels of water scarcity globally, rendering it the most water-deprived region (Waal et al., 2023). In the MENA area, both surface and groundwater resources, approximately two-thirds of which are shared across borders, are subject to substantial stress and overutilization due to rising demand. Lebanon epitomizes this crisis, contending with a host of issues, including water scarcity, pollution, mismanagement, and political instability. As of 2019, a significant decline in the average daily water availability per capita to 35 liters has resulted in severe water shortages for 70% of Lebanon's population (Ferrando, 2022). The situation is further aggravated by Lebanon's deteriorating water infrastructure and frequent power outages, leading to inconsistent access to clean water for numerous households. Moreover, the ongoing political and economic turmoil in Lebanon has impeded necessary investments in vital water infrastructure, exacerbating the predicament. Consequently, the Lebanese populace is facing a dire situation, struggling with water shortages, associated health risks, and the ongoing challenge of securing safe and dependable water sources.

The pilot projects initiated as part of this project will specifically address identified problems in the targeted areas. The interventions will focus on Agricultural water management, Afforestation, and flood management measures through the implementation of Nature-based solutions and community empowerment.

The Al Murunah Project in Lebanon is slated for execution in three specific localities: Al Qaa, Ras Baalbeck, and Fekha. Figure 2 in the report illustrates the geographic positioning of these localities.

Geographically, the study area is situated in the northeastern part of Lebanon, within the Bekaa region. It primarily encompasses the villages of Ras Baalbeck, Fekha, and Qaa, along with their adjacent areas. The study area can be bifurcated into two distinct sections based on their watersheds. The lower section includes the plains stretching between Laboueh and Qaa and their associated urban areas. Meanwhile, the upper section encompasses the peripheral areas of Ras Baalbeck and Aarsal villages, along with the defined watersheds. This geographical delineation is critical in understanding the distinct hydrological characteristics and challenges present in each area, thereby informing the tailored implementation of the Al Murunah Project's initiatives.

Within this framework, the "Al Murunah" Project, funded by the

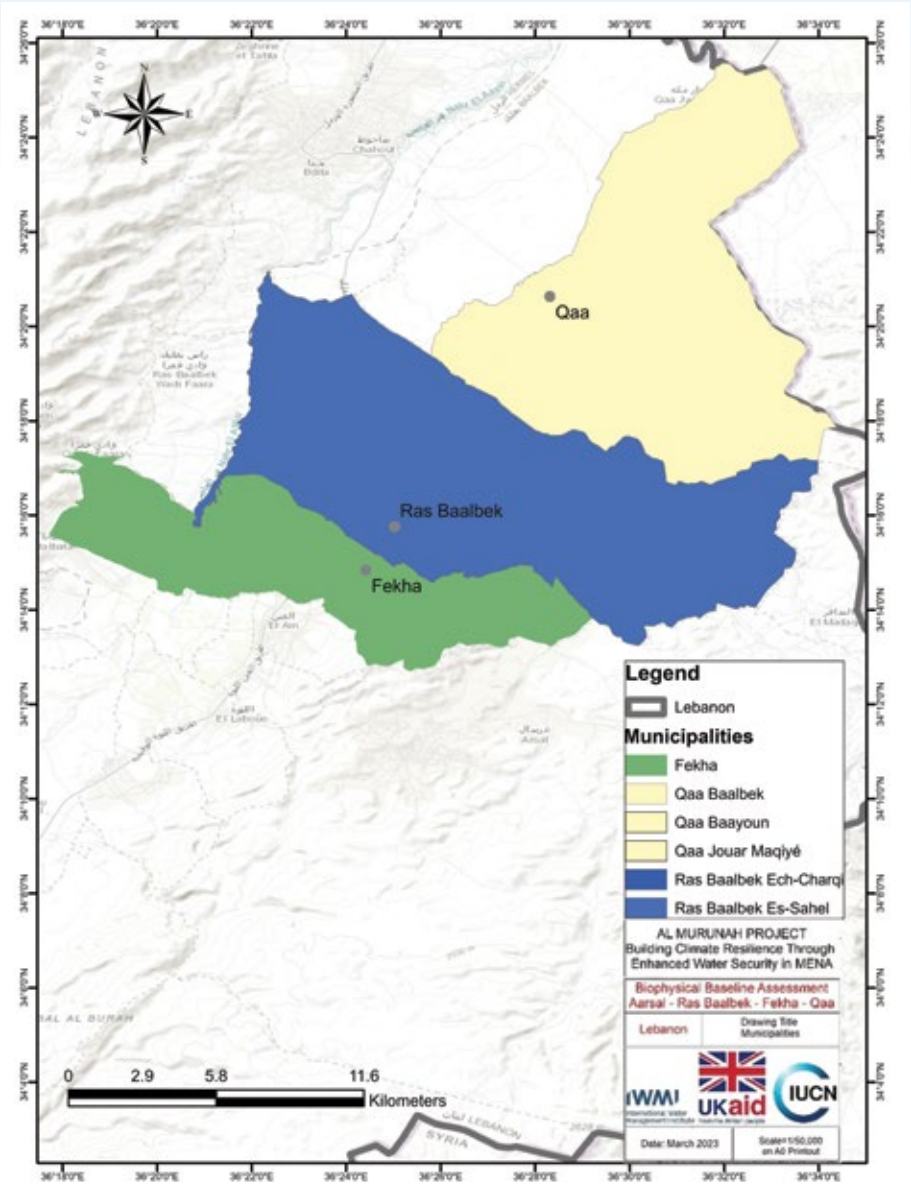


Figure 2: Geographic boundaries of the study area (Source: CNRS, 2018)

UK government and implemented by the International Water Management Institute (IWMI) in partnership with the International Union for Conservation of Nature (IUCN), is committed to improving water security and enhancing climate resilience in the Middle East and North Africa (MENA) region. This initiative is achieved by executing Resilient Nature-based Water Solutions (RNBWS) aimed at both general Water Management and Agricultural Water Management (NBSW and AWM, respectively). The project targets four countries: Jordan, Lebanon, the Occupied Palestinian Territories, and Egypt.

This baseline report is focused on analyzing and providing insights into the implementation of the Al Murunah Project in Lebanon.

This baseline assessment serves a crucial purpose in providing a comprehensive understanding of the existing conditions in Al Qaa, Ras Baalbeck, and Fekha, particularly regarding water resources, agriculture, and climate change impacts. It aims to establish a baseline of the socio-economic, demographic, and environmental factors in the region, which are essential for justifying and supporting the planning of interventions. By identifying key challenges, a foundation for designing effective interventions will be developed. It enables informed decision-making and helps prioritize areas requiring immediate attention.

Climate, land, and water features

Topography, climate, and climate change projections

The topographical landscape of the study area is distinctly characterized by a combination of sloping to gentle lands, along with rugged and mountainous terrain. Located in the foothills of the Anti-Lebanon mountains, this region exhibits a wide range of elevations, varying from 700 to 2,600 meters above sea level. Its geographical features are marked by numerous wadis (dry riverbeds), which play a crucial role in the area's drainage, leading westward into the Assi River and eastward into the Bekaa Valley. This topography, predominantly steep and rocky, is interspersed with narrow valleys and ridges, contributing to a complex and intricate landscape.

Within this varied topography, the flat areas, which have a slope of 0-8%, are particularly dominant. These areas can be divided into two main parts: the Bekaa Valley and extensive tracts in the northern section of the Anti-Lebanon mountains. One of the notable flat areas is the Laboueh to Qaa plain, a relatively level and open space stretching for about 25 kilometers from the town of Laboueh in the south to the town of Qaa in the north.

Positioned at an elevation ranging between 1,000 and 700 meters above sea level, this plain stands as a significant agricultural zone. Here, farmers engage in the cultivation of various crops, including wheat, barley, and a range of fruits. This agricultural activity is pivotal to the region, both economically and in terms of the sustenance it provides to the local communities.

Lebanon, situated on the eastern coast of the Mediterranean, is characterized by a Mediterranean climate. This climatic pattern is defined by a distinct seasonality in precipitation, with about 80% of the annual rainfall occurring between October and March. This seasonal distribution of rainfall leads to periods of water scarcity during the dry months of June, July, and August.

The Lebanese Meteorological Service categorizes Lebanon into three primary climatic zones: Coastal, Mountainous, and Internal. These zones are further subdivided into eight regions, each exhibiting unique climatic features. This segmentation is essential for understanding the diverse weather patterns across the country. Additionally, there are multiple monitoring stations within

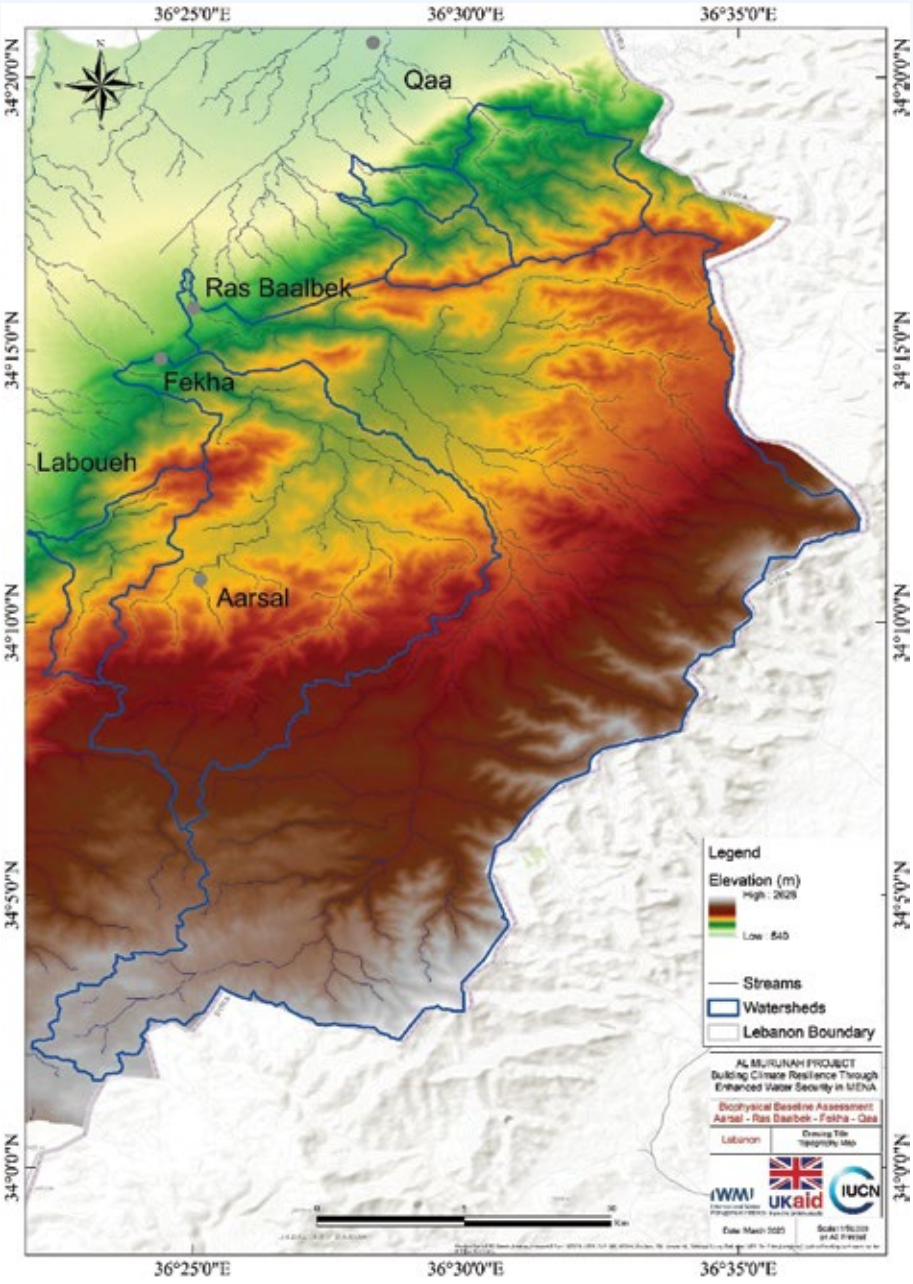


Figure 3*:* Study area topography (Data source: CNRS, 2018)

these regions, ensuring accurate and comprehensive data collection on climatic conditions.

Each of these climatic zones receives varying amounts of annual precipitation, as illustrated in Figure 4. The Coastal areas typically receive between 600 mm and 1,100 mm of rainfall annually. Mount Lebanon, known for its higher altitude, receives a higher average annual precipitation, amounting to approximately 1,210 mm. The Beqaa Valley, which lies in a more sheltered position, has an average annual precipitation of around 700 mm. These variations in rainfall are significant for agricultural planning, water resource management, and understanding the hydrological dynamics of each region.

The climatic dynamics of Lebanon are significantly influenced by prevailing westward winds from the Mediterranean Sea, which bring much-needed precipitation to the region. A key factor in this process is orographic lifting, particularly evident over Mount Lebanon. This phenomenon causes the heaviest rainfall to occur on the western side of the mountain range, with the amount of precipitation decreasing sharply eastward, past the crest.

As a result, the interior regions, including drier areas like Hermel and Baalbeck, receive only residual rainfall from Mount Lebanon. The study area specifically lies within the northern inland Lebanon's continental eco-climatic zone. This zone receives annual rainfall ranging from 100 to 700 mm, with the higher amounts typically observed in the eastern mountainous regions. Rainfall is most prevalent from October to March, peaking in January, while a dry period dominates from April to October. The region is also susceptible to occasional flash floods, particularly due to autumn thunderstorms and spring rain showers.

Meteorological data gathered from stations installed before 1975 indicate that the average precipitation in areas like Aarsal (325 mm), Qaa (240 mm), and Fekha (200 mm) is lower compared to the national average for Lebanon. Aarsal, in particular, often experiences winter snowfall, which plays a crucial role in replenishing groundwater storage.

In terms of temperature, Fekha has an annual average of 15.3°C, while Qaa is slightly warmer with an average of 17°C. The region experiences significant temperature extremes, ranging from lows of -10°C in January to highs of 38°C in August, underscoring the substantial monthly fluctuations in climate. Additionally, Fekha has an average annual relative humidity of 56%, with a notably drier summer (average humidity of 46%) characteristic of the continental Mediterranean climate prevalent in the region. These climatic variations are critical for understanding the ecological and agricultural conditions of the area, influencing water resource management and agricultural practices.

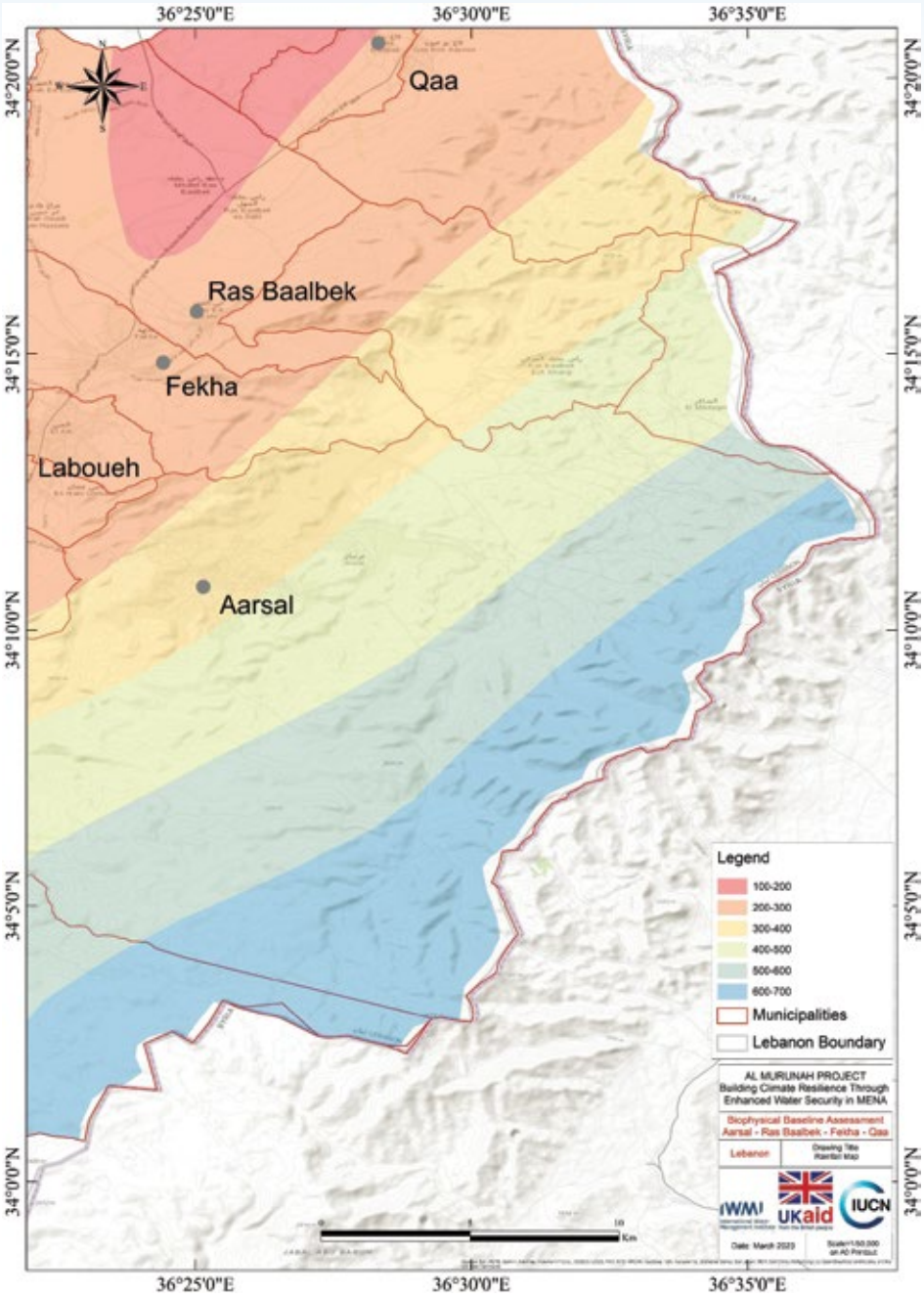


Figure 4*:* Precipitation map (Data source: (FAO WAPOR, 2022))

Table 1: Monthly average daytime temperature (C)
(Data source: Atlas Climatique du Liban, 1977)

Station\ Month	Sep	Oct	Nov	Dec	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug
Fekha	20.6	18.0	12.9	7.9	5.4	6.6	9.3	13.5	18.5	22.4	23.9	24.1
Qaa	23.1	18.4	13.7	8.9	7.5	8.3	11.9	16.0	20.4	24.4	25.8	25.8

Table 2: Monthly relative humidity (%)
(Data source: Atlas Climatique du Liban, 1977)

Station\ Month	Sep	Oct	Nov	Dec	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug
Fekha	53	52	58	64	69	69	61	57	47	44	48	46
Qaa	57	55	62	62	62	62	71	80	83	77	67	60

The climatic network in Lebanon, even before 1975, was somewhat underdeveloped despite the Lebanese Meteorological Service (LMS) having installed a substantial number of weather stations across the country. At that time, the LMS managed a network of 140 weather stations, which provided coverage across various regions of Lebanon, including the areas of interest in this study.

As of the current period, the number and locations of weather stations that are actively operational have changed. The details of the existing weather stations, including their specific locations and the type of data they collect, are enumerated in Table 3 of the report. This table is a valuable resource for understanding the current capacity for meteorological data collection in Lebanon, particularly in the study area. The data from these weather stations is crucial for accurate weather forecasting, climate research, and informed decision-making in areas such as agriculture, water resource management, and disaster preparedness. The establishment and maintenance of a robust climatic network are vital for monitoring environmental changes and for the successful implementation of projects like the Al Murunah Project, which rely heavily on accurate and timely climatic data.

Table 3: List of weather stations currently installed within the study area
(Data source: NWSS,2020)

Station	Long	Lat	Altitude	Authority
Aarsal	36.42	34.18	1424	LARI
Qaa	36.51	34.39	583	LARI
Ras Baalbeck	36.42	34.26	1060	LARI
Qaa	36.50	34.40	513	LMS - DGCA

Analysis of the impact of climate change

The effects of climate change in Lebanon have been extensively studied and reported through various national communications to the United Nations Framework Convention on Climate Change (UNFCCC). These reports, prepared and submitted by Lebanon's Ministry of Environment (MoE), provide a detailed analysis of the country's climate situation and projections for the future. Key communications were developed in the years 2016 ,2011, and 2022, each employing advanced climate modeling tools to enhance the accuracy and relevance of their findings.

These communications have utilized sophisticated climate models to project the impacts of climate change in Lebanon. Among these models are the PRECIS Regional Climate Model (RCM), the MENA CORDEX RCM, and the Coupled Model Intercomparison Project Phase 6 (CMIP6). Each of these models offers different capabilities and insights, contributing to a more comprehensive understanding of climate dynamics in Lebanon.

The most recent analysis, as per the 2022 communication, is based on the findings and methodologies outlined in the Intergovernmental Panel on Climate Change's Sixth Assessment Report (AR6). The AR6 is recognized for providing the latest and most comprehensive assessment of the science related to climate change. It offers insights into future climate scenarios, which are crucial for countries like Lebanon in strategizing their adaptation and mitigation efforts.

This series of national communications underscores Lebanon's commitment to addressing climate change and its dedication to informed policymaking through the use of cutting-edge scientific research and data. These efforts are essential not only for national planning but also for Lebanon's contributions to global climate change discussions and initiatives.

The impact of climate change in Lebanon, as indicated by various climate models, presents a significant challenge for the country in the coming decades. Key findings from these models include:

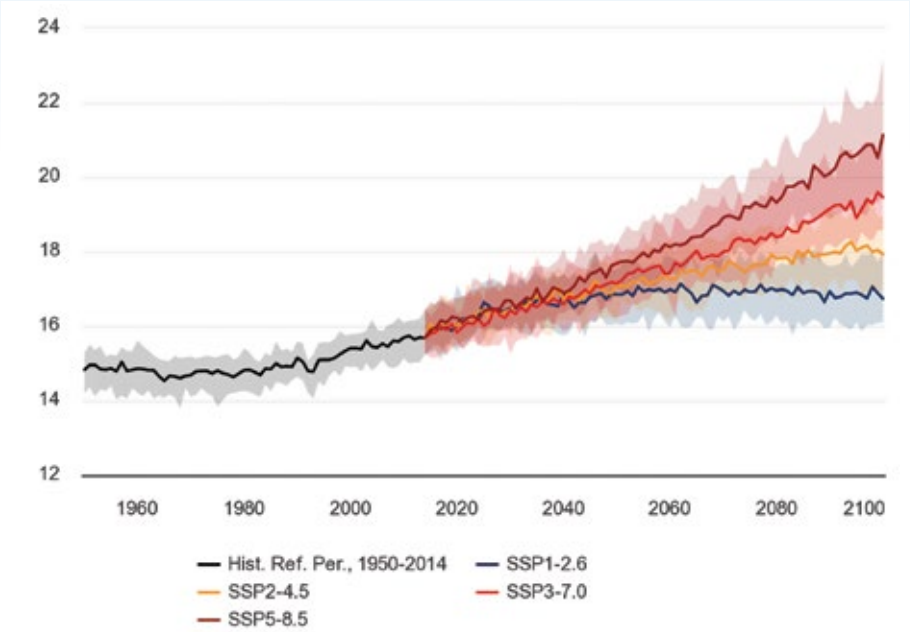


Figure 5*:* The projected mean temperature for Lebanon using a multi-model ensemble with a baseline period 1995-2014 (Data source: WorldBank, 2021)

Temperature increase: Climate models project a significant rise in annual mean temperatures for Lebanon. Compared to the reference period of 1986-2005, an increase of 1.6°C to 2.2°C is expected by mid-century and 2.2°C to 4.9°C by the end of the century. More Lebanon-specific models forecast an average temperature rise of around 1.2°C between 2021-2040 and 2°C between 2041-2060.

Precipitation decrease: There is an anticipated decrease in precipitation of 5.6% to 9% by mid-century and 9% to 22% by the end of the century, according to Representative Concentration Pathway (RCP) scenarios. These projections are more severe than earlier estimates, attributed to higher temperatures and shorter timeframes.

Increased drought risk: The risk of drought is expected to rise, particularly for the periods 2021-2040 and 2041-2060. Southern regions and coastal areas are likely to be more severely affected.

Heat waves: The frequency and intensity of heat waves are predicted to increase, particularly affecting urban areas and leading to higher energy consumption for cooling. The number of days with temperatures exceeding 35°C and 40°C could nearly double by 2041-2060 compared to the period 1995-2014.

Extreme weather events: Lebanon is expected to experience an increase in extreme weather events related to temperature, precipitation, drought, and flooding. The occurrence of compound heatwaves and droughts could rise

almost fivefold by 2041-2060. Natural disasters such as floods, heatwaves, and strong winds have already caused significant damage to agriculture and infrastructure, with floods being particularly destructive.

Economic losses: The direct economic losses to Lebanon's agricultural sector due to climate change-related disasters were estimated at USD 605 million in 2018. These losses were a result of various extreme weather events, including floods, cold waves, winter storms, heavy rainfall, heat waves, wildfires, strong winds, and landslides.

In summary, Lebanon faces a range of climate change impacts, including rising temperatures, decreasing precipitation, heightened drought risks, more frequent and intense heat waves, an increase in extreme weather events, and considerable economic losses due to these climate-related disasters. These challenges highlight the critical need for effective adaptation and mitigation strategies to address the impacts of climate change in Lebanon.

Agroecological and cropping zones

The study area, spanning approximately 1000 km^2, is characterized by a varied relief, with some regions exceeding 1500 meters in elevation. This topographical diversity is primarily a result of uplift and tectonic activities that have occurred over the past 80 million years, with a significant intensification in the last 20 million years. The Beqaa plain, a part of the Mediterranean rift system, is flanked by the eastern rise of the Anti-Lebanon mountain range and the western uplift of Mount Lebanon. The region is marked by a dense network of geological faults, including the notable Serghaya fault that extends towards Aarsal. Many faults in the uplifted eastern blocks predominantly run in an east-west direction, branching from the major fault line.

The surface geology of the area reveals various joints and diagenetic discontinuities, indicating periods of stress and geological changes associated with the uplift. These structural characteristics significantly influence the topography and also affect surface processes. The extensive network of structural discontinuities plays a key role in soil formation processes, such as karstification, which enhances water infiltration, soil profile development, and the formation of Terra rosa soils.

Moreover, the geological history of this area showcases a sequence of changing environments and tectonic influences over time, contributing to the region's rich biodiversity. This is evidenced by the presence of fossils such as mollusks, ammonites, and foraminifera.

As per the Soil map of Lebanon (Darwich, 2006), the predominant soil types in the study area include Leptosols (60%), Regosols (14%), Calcisols (14%), Fluvisols (7%), Cambisols (3.4%), with minor occurrences of Luvisols and Anthrosols (2%). The soil map in Annex 1 illustrates the higher-level soil distribution, while a detailed breakdown of the soil types is provided in the accompanying table.

For the assessment of Land Use/Land Cover (LULC) in the study area, a geospatial analysis was carried out using the CORINE Land Cover classification system based on SPOT 6 data verified in 2017. This analysis revealed that natural formations such as bare rocks, bare soil, and rocky outcrops constitute the majority of the land cover (60%). Agricultural terraces cover around 13% of the area, and fruit trees account for 10%. The remaining 17% is comprised of various land cover types, including scrublands, extraction sites, vineyards, and urban areas.

The LULC distribution underscores a predominantly rural landscape with significant natural outcrops and agricultural lands. Industrial activities are relatively limited in the area. The prevalence of bare rocks and grasslands poses challenges for regions like Aarsal. The imbalance between forested areas and other land use classes contributes to the land's vulnerability, particularly to recurrent flooding. Strategies such as expanding terraced lands for fruit tree cultivation, reforestation, and water harvesting practices are recommended to enhance soil and land conservation in the area (Table 4, Figure 6).

Table 4: Distribution of LULC in the area (Data source: CNRS, 2018)

LULC Type	Area (km^2)	Cover Ratio (%)
Bare Rocks	488	49.5%
Field Crops in Medium to Large Terrace	124	12.6%
Fruit Trees	100	10.1%
Bare Soil	77	7.8%
Scrubland	37	3.8%
Abandoned Agriculture Land	19	2.0%
Scrubland with Some Dispersed Bigger Trees	18	1.9%
Rocky Outcrops	17	1.8%
Clear Juniper	17	1.7%
Mineral Extraction Site	15	1.5%
Field Crops in Small Fields/Terraces	13	1.3%
Medium-Density Urban Fabric	13	1.3%
Vineyards	12	1.2%
Other	36	3.65%

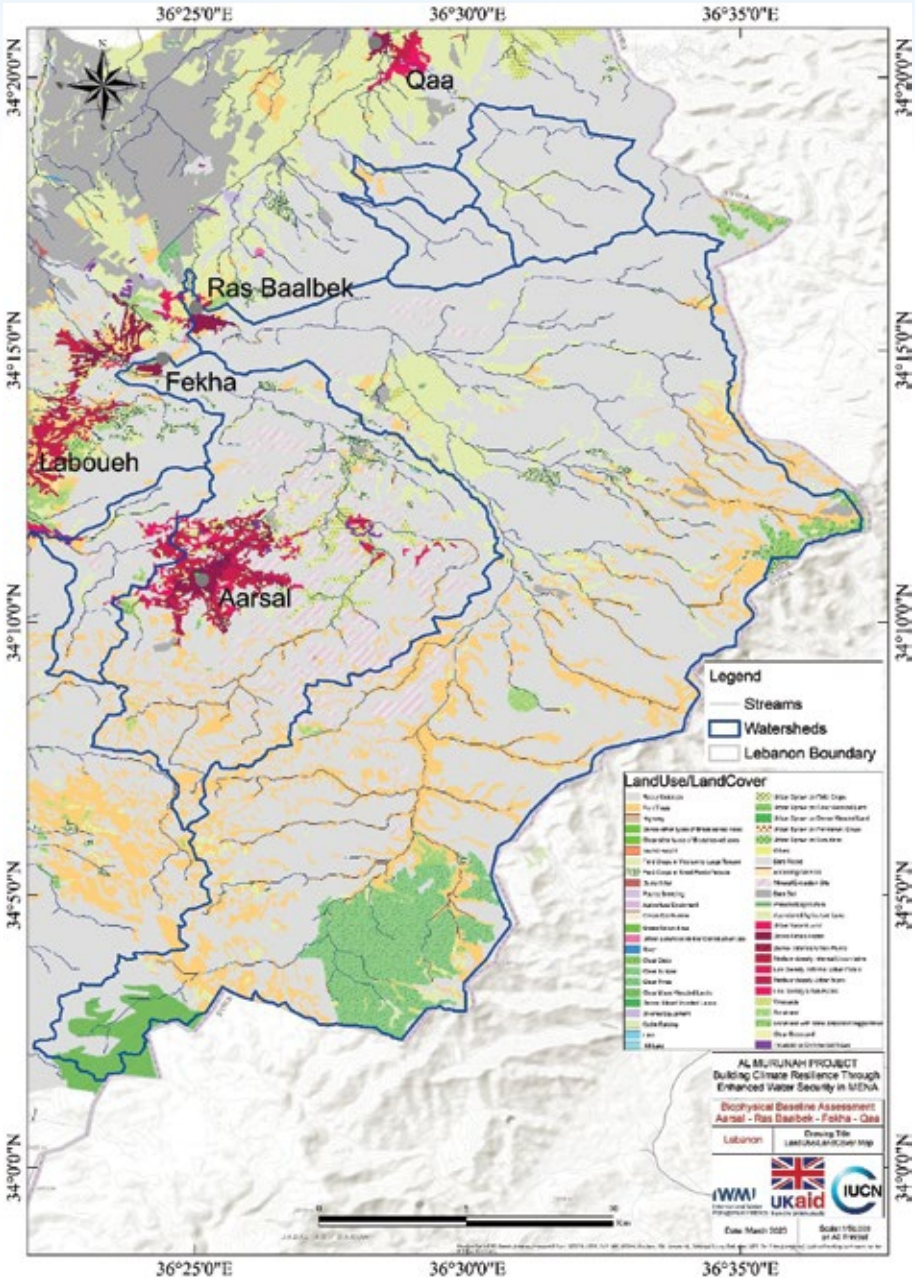


Figure 6: LULC map of the study area (Data source: CNRS, 2018)

Water resources and infrastructure features

Irrigation development

In the current agricultural landscape, approximately 25% of the study area is utilized for rainfed fruit trees and irrigated agriculture. This practice is sustained by several advantages, such as the region's dry, warm climate and low altitude, enabling the early production of various leguminous crops. Despite being situated in a continental eco-climatic zone with low population density and limited access to markets, agricultural activities have seen growth due to high crop prices. Roughly 50% of the local population is engaged in agriculture.

Crop production in the area is divided between North Bekaa, where both dryland and irrigated crops are cultivated. Dryland crops like wheat, barley, lentils, chickpeas, melons, grapes, and more dominate the landscape, covering about 75% of arable land. Irrigated crops include grains, maize, vegetables, deciduous fruits, legumes, and various other crops.

The total agricultural area encompasses around 27,500 hectares, with about 9,200 hectares (34%) under irrigation. The primary crops grown are field crops (51% of the irrigated area), followed by fruit trees (36%), vineyards (4%), olives (1%), and other types of agriculture (0.2% protected agriculture and 7% abandoned lands.

Irrigation sources comprise springs, public and private wells, ponds, and hill lakes. Farmers employ different irrigation methods, including drip, sprinkler, and surface irrigation. Public irrigation canals stretch over approximately 465,000 linear meters in North Bekaa. Concrete canals account for 62% of these networks, followed by earthen canals (19%), mixed (15% concrete and earthen), and pipes (4%).

Two major irrigation schemes (Tables 5-6) are described in more detail:

1. Laboueh scheme:

- Encompasses Laboueh, Qaa, Fekha, Harbata, Zabboud, Ain Baalbeck, Bajjaje, and Nabi Osman villages.
- Agricultural area: 12,330 hectares; irrigated: 60%.
- Crops include field crops, fruit trees, vegetables, olives, and grapes.
- Main irrigation methods: drip (67%), sprinkler (4%), surface (29%).
- Current irrigation efficiency: 57.5%.
- Water sources: Laboueh and Fekha springs, groundwater wells.
- Current demand: 98 mm^3/year; projected demand by 2040: 130 mm^3/year.
- Gap between demand and supply: 61 mm^3.
- Recommended improvements: canal rehabilitation, on-farm water meters, Assi Dam, hill lake system, and network extension.

2. Ras Baalbeck scheme:

- Covers Ras Baalbeck el Charqi, Ras Baalbeck el Gharbi, Ouadi Faara, and Ras Baalbeck al Sahel villages.
- Agricultural area: 2,845 hectares; irrigated: 63%.
- Crops include field crops, fruit trees, vegetables, olives, and grapes.
- Main irrigation methods: drip (28%), sprinkler (4%), surface (68%).
- Current irrigation efficiency: 35.9%.
- Water sources: Local springs.
- Current demand: 33 mm^3/year; projected demand by 2040: 43 mm^3/year.
- Gap between demand and supply: 33 mm^3.
- Recommended improvements: canal rehabilitation, on-farm water meters, Ras Baalbeck Hill Lake.

Additionally, in the mountainous areas above the Bekaa Plain, irrigation is practiced using water from springs in narrow valleys. These areas have small, non-continuous plots with varying water availability. Water use efficiency is low, and losses from poorly constructed canals are significant. Regulatory efforts are lacking, leading to wastage and inefficient water use.

Improving irrigation efficiency, upgrading canal systems, and implementing water-saving technologies are crucial steps to ensure sustainable agricultural practices and mitigate water scarcity challenges in the region.

Table 5: Irrigation scheme characteristics in the study area (Data source: IMP, 2018)

Schemes	Laboueh	Ras Baalbeck
Area Agricultural (ha)	12,330	2,845
Area Irrigated (ha)	7,398	1,792
Area Irrigated/ Area Agricultural (%)	60	63
Mapped Canals (l.m.)	106,063	12,601
Length of Additional Canals Needed (l.m.)	36,500	-

Table 6: Irrigation schemes' water balance (Data source: IMP, 2018)

Schemes	Laboueh	Ras Baalbeck
Total Defined Supply	37.08	0.12
Total Current Demand	98.42	32.84
Current Gap in Public Supply	61.33	32.72
Total Demand by 2040	130.3	43.09
Seasonal Scenario-based supply	6.1	0.01
Additional Gap in Public Supply by 2040	87.12	42.96
Water Saved by improving efficiencies	36.81	19.91
Reused TSE	8.4	0
Dams	27.87	0
HLs by SDATEL	0	0.2
HL by IMP	1.55	0
Remaining Gap by 2040	12.49	0

Water resources

Surface water resources

The study area, characterized by low precipitation levels, experiences minimal surface runoff, a condition largely attributed to its geological formations and modified drainage channels. Despite the scarcity of surface water, the region is prone to flash floods, particularly in the steep, rural mountainous areas. These flash floods can lead to rapid and forceful flooding in downstream locations.

A notable geographical feature of this area is the absence of perennial rivers. This lack is somewhat mitigated by the presence of numerous springs, primarily originating from the base of the Anti-Lebanon Mountains and flowing in a northwest direction. These springs, including Laboueh, Fekha, and Nabaa Raayane, are crucial water sources for the region. They are extensively used for various purposes, such as irrigation, livestock watering, and domestic water supply. However, the management and sustainable use of these springs are challenged by the limited availability of hydrometric data, which makes accurate measurement and monitoring difficult.

Among these springs, Nabaa el Laboueh stands out as the second-largest spring in the Nahr el Assi Basin. It plays a significant role in the local water economy, primarily contributing to irrigation and domestic water supply. The water from Nabaa el Laboueh forms an intricate network of smaller springs

and irrigation canals downstream, which are vital for agricultural activities in the region (MoEW & UNDP, 2014).

Water supply and management

Characteristics as locations and average flows

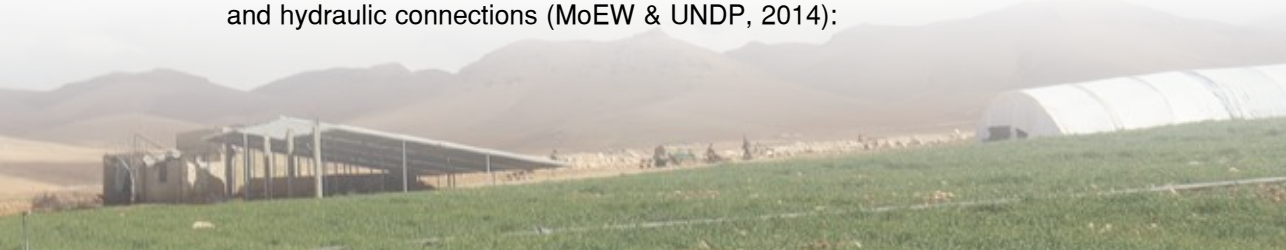
In the study area, water supply and management are structured around four main systems, each serving the communities of Aarsal, Ras Baalbeck, Fekha, and Qaa. These systems are primarily based on the use of reservoirs for water storage and distribution, reflecting the unique needs and resources of each locality:

- Aarsal System: This system depends on three reservoirs, which together have a total storage capacity of 5,500 cubic meters. These reservoirs are critical in supplying water to the Aarsal area.
- Ras Baalbeck System: In Ras Baalbeck, water management is facilitated by three reservoirs with a combined capacity of 3,000 cubic meters. These reservoirs play a key role in storing and distributing water in the region.
- Fekha System: The Fekha system also comprises three reservoirs with a total water storage capacity of 3,000 cubic meters. This system is notable for its existing pumping station and an additional station that is proposed to enhance its capacity.
- Qaa System: Serving the Qaa area, this system utilizes two reservoirs with a combined capacity of 1,000 cubic meters. Plans for this system include a proposed pumping station to improve water distribution.

Alongside these localized systems, the Updated National Water Supply Strategy (NWSS) of 2020 lays out a broader framework for meeting the water demands across Lebanon. The NWSS proposes a variety of projects aimed at enhancing the water supply infrastructure. These projects include drilling new wells, constructing transmission lines, and modernizing the existing water network. A significant focus of the strategy is on improving efficiency through the adoption of automation and supervisory control and data acquisition (SCADA) systems. These technological interventions are intended to reduce water losses and optimize the overall management of water resources. This comprehensive approach is crucial for addressing the water supply challenges in the study area and across Lebanon, particularly in light of the increasing demands and changing climatic conditions.

Groundwater resources

The groundwater resources in the study area are significantly shaped by the region's geological formations and structural features. Three main basins have been identified, each with distinct aquifer characteristics, flow directions, and hydraulic connections (MoEW & UNDP, 2014):



Northern Anti-Lebanon Cretaceous Basin (Basin 7c):

- **Location:** This basin is situated in the northern Bekaa zone, at the foothills of the Anti-Lebanon Mountains.
- **Geological Formation:** It is formed by the western limb of the Anti-Lebanon anticline and the eastern limb of the Bekaa syncline.
- **Groundwater Flow:** The predominant direction of groundwater flow is towards the west and southwest.
- **Natural Outlets:** Major natural groundwater outlets in this basin are springs, such as the Ras Baalbeck and Younine Springs.

Eastern Bekaa Eocene Basin (Basin 10):

- **Location:** Positioned at the foothill of the Anti-Lebanon range, primarily in the central and northern parts of the Bekaa plain.
- **Geological Formation:** This basin is formed by the northern part of the Sohmor syncline and the western limb of the Anti-Lebanon anticline.
- **Groundwater Flow:** In the southern part of this basin, groundwater flows from northeast to northwest, while in the central and northern parts, it flows from northwest to west.
- **Natural Outlets:** Springs along the aquifer contact, like the Faaour and Ras el Ain springs, act as natural outlets for groundwater.

Northern Bekaa Neogene-Quaternary Basin (Basin 11b):

- **Location:** This basin encompasses the core of the Bekaa plain and is divided into two sub-basins: Southern and Northern.
- **Geological Composition:** It mainly consists of Neogene conglomerates with calcareous cement and Quaternary non-consolidated deposits.
- **Groundwater Flow:** In the northern part, groundwater flows from northwest to northeast and is hydraulically connected to neighboring aquifers.
- **Budget Values:** Some areas of this basin are experiencing negative budget values, indicative of overexploitation and declining groundwater levels.

Understanding the characteristics of these basins is crucial for effective groundwater management and conservation in the region. The varying flow directions, aquifer types, and the presence of natural springs all play integral roles in the hydrogeological dynamics of the area. Addressing issues such as overexploitation and ensuring sustainable use of these vital groundwater resources are essential for the long-term water security of the region.

Table 7 presents a detailed account of the groundwater budgets within three distinct basins (Figure 7) in Lebanon, revealing varied conditions of surplus and

deficit that point toward differences in potential overexploitation or unexploited reserves. In Basin 7c, which is part of the Northern Anti-Lebanon Cretaceous region, there is a consistent surplus in the groundwater budget, evident in both dry and wet seasons. This surplus, coupled with the substantial contribution from springs, indicates a potential for sustainable water extraction. The large total recharge volumes suggest that the basin's groundwater resources are being replenished at a rate that exceeds current usage levels.

Table 7: Groundwater basins budget (Data source: MoEW & UNDP, 2014)

Basin No		7c	10	11b
GW Basin		N. Anti-Lebanon Cretaceous	E. Bekaa Eocene	N. Bekaa Neogene-Quaternary
Total Basin Area Km^2		670.4	123	680.2
Infiltration MCM	Dry 10–11	309.4	40.5	50
	Wet 11–12	423.5	59.1	79.5
Return Flow MCM		5.4	25	55.2
Gain MCM		ND	ND	ND
Total Recharges	Dry 10–11	314.8	65.6	105.2
	Wet 11–12	428.9	84.2	134.7
Domestic Supply Sources MCM	Public Wells	6.2	5.6	0
	Springs	0	0	0
	Private Wells	1.6	0.1	29.6
Agricultural Usages MCM	Wells	2.8	50.3	106.8
	Springs	1.1	4.7	3
Springs MCM		104.1	0	0
Loss MCM		ND	ND	ND
Total Discharge MCM		115.7	60.8	139.4
Budget MCM	Dry 10–11	199.1	4.8	- 34.2
	Wet 11–12	313.2	23.4	- 4.7
Budget/Area mm	Dry 10–11	297	39	- 50
	Wet 11–12	467	190	- 7

Basin 10, the Eastern Bekaa Eocene area, exhibits a small surplus during wet years, signifying that seasonal recharge can sometimes meet or exceed the basin's water demand. However, during dry years, this basin experiences a slight deficit. This fluctuation between surplus and deficit indicates that the water balance in this basin is sensitive to annual precipitation variations, necessitating careful management to avoid overexploitation. Basin 11b, located in the Northern Bekaa Neogene-Quaternary region, presents a situation of concern. The consistent deficits in both dry and wet years suggest that groundwater extraction surpasses the natural recharge rate. The high agricultural water usage from wells, as indicated by the table, could be a significant factor contributing to this deficit. The negative budget values per area further reinforce the critical state of overexploitation. If current extraction rates continue, there could be a risk of groundwater depletion, leading to a decline in water levels and long-term sustainability issues for the aquifer.

The table also highlights the need for improved data collection and monitoring. The "ND" (no data) entries for certain parameters, such as gains and losses, emphasize the uncertainties that exist within the groundwater budget estimations. Accurate and comprehensive data collection is essential to inform better management strategies and to ensure the long-term viability of water resources in these regions. Overall, the disparities in groundwater budgets across the three basins underscore the importance of region-specific management strategies. Such strategies should consider the unique hydrogeological characteristics of each basin, the seasonal and annual variability in water availability, and the current and projected demands on water resources. Implementing measures to control groundwater extraction, promote efficient water use, and enhance recharge where possible will be critical in addressing the challenges highlighted by the groundwater budget analysis.

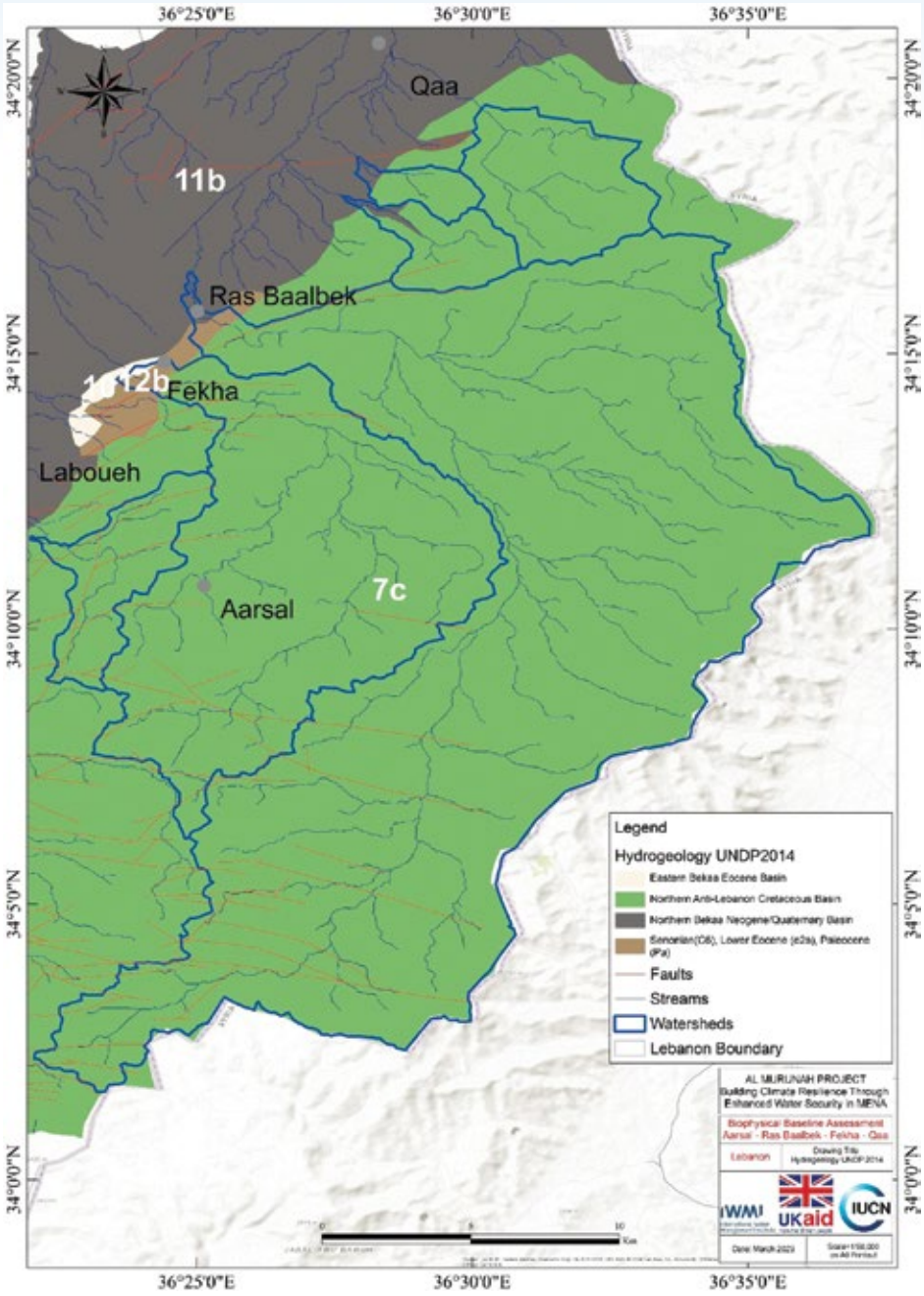


Figure 7: Groundwater aquifers (Data source: CNRS, 2018)

Water quality and pollution sources

Water quality in Lebanon faces significant challenges due to pollution from various sources, leading to the deterioration of rivers, springs, wetlands, and aquifers. The main contributors to this problem include uncontrolled pollution from point sources, such as specific discharge locations, and non-point sources, like diffuse pollution spread over a large area. The pollution is primarily driven by factors such as rapid population growth, insufficient waste management infrastructure, and the absence of comprehensive monitoring programmes. The situation is further strained by the influx of approximately 1.5 million refugees, which has put additional pressure on the already inadequate waste management systems and has led to an increase in pollution due to the lack of effective surveillance and control systems. The public health implications are severe, as the use of contaminated water is associated with outbreaks of diseases, posing risks to the health of the population and resulting in economic burdens.

To tackle these issues, various initiatives have been undertaken. For instance, the Lebanon Water Quality Survey (LWQS), a collaboration between WHO and UNICEF, was conducted to assess the quality of household water. This survey measured parameters such as E. coli presence, free chlorine levels, nitrates, and turbidity to understand the extent of water contamination. The findings indicated regional disparities in water quality, with certain areas showing evidence of contamination by E. coli while others displayed risk reduction practices. Academic institutions have also played a role in assessing water quality. The American University of Beirut (AUB) conducted studies focusing on the presence of fecal indicator bacteria, including fecal coliforms and E. coli, in river waters. Notre Dame University (NDU) researched the water quality of the Al Assi River, noting the impact of human activities within its watershed and the variation in contamination levels along its course. In the study area, the contrast between the upper rural parts and the lower downstream sections is apparent. The upper part, with minimal habitation, generally experiences fewer water quality issues. In contrast, the lower part, particularly downstream of Ras Baalbeck, is more susceptible to pollution from untreated wastewater and agricultural runoff.

The issue of water pollution in Lebanon requires immediate and sustained intervention. It is crucial to implement measures that enhance waste management, establish effective monitoring systems, and promote pollution control practices. These steps are vital to ensure the safety of water resources, safeguard public health, and protect the ecological integrity of the country's water systems.

Wastewater

There are no existing treatment plants or collection networks in the area, and residents mainly rely on septic tanks. However, proposed wastewater networks and treatment plants were included in the Updated NWSS 2020.

Brief examples of NbS applications focused on water management in the country

The field visit on March 28th, 2023, to assess flood protection structures in Ras Baalbeck and Qaa provided valuable insights into the condition and effectiveness of these structures. The visit revealed several key points about the state of flood protection in these areas (Figure 8):

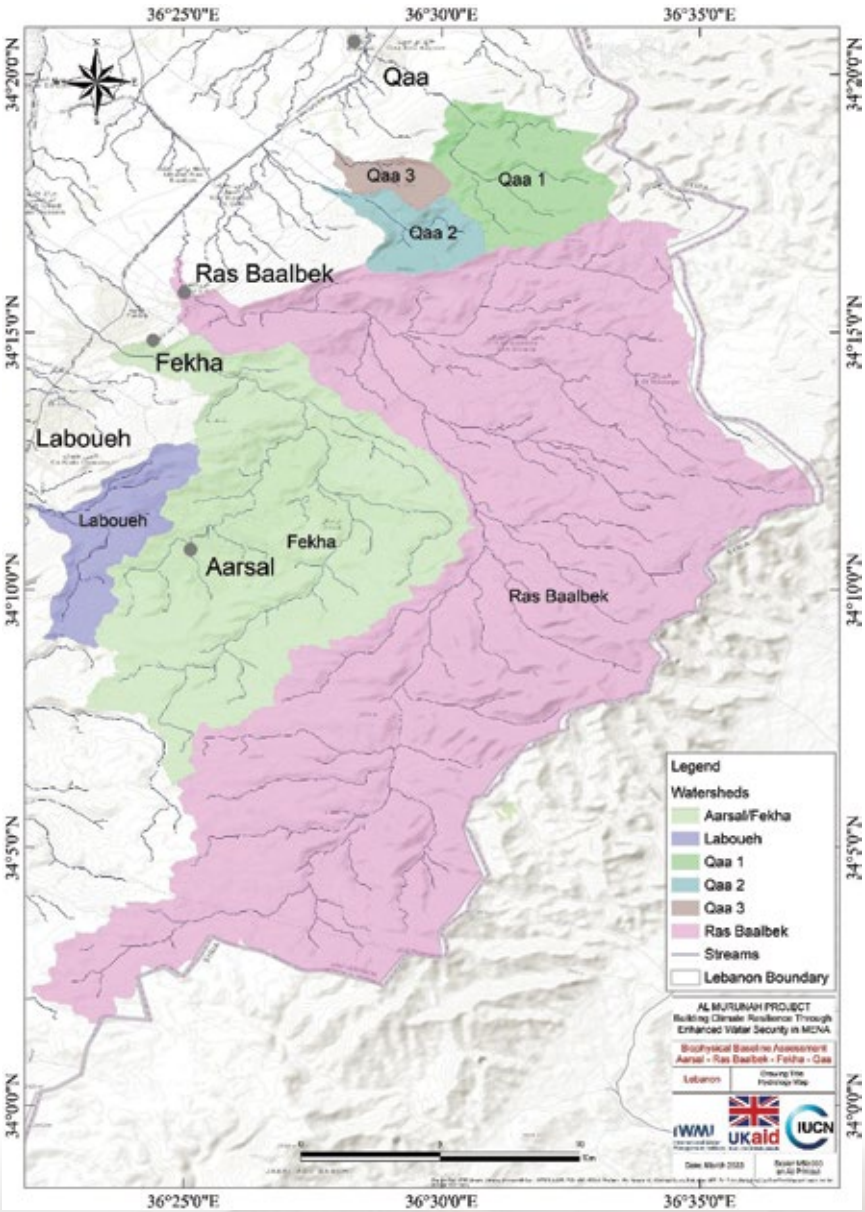


Figure 8: Hydrogeology features in the study area (Data source: CNRS, 2018)

Ras Baalbeck:

A significant flood protection measure in place since before 2011 in the Ras Baalbeck watershed consists of 22 consecutive ponds along the mainstream in Sahlet Tahoun el Haoua, covering 1700 meters. However, historical satellite imagery indicates that these structures have deteriorated over time due to floods, particularly between February 2013 and March 2021. Notably, the first seven ponds were completely destroyed by a flood in June 2018, with earth ridges and walls eroding over time.

- In Wadi el Tiné, near Khirbet el Khechen, a stone check dam and gabion walls intended for flood mitigation were found to be extensively damaged, with eroded stones and sediments filling them. This damage is reminiscent of the degradation observed in Sahlet Tahoun el Haoua.
- Within the Ras Baalbeck watershed, originally, there were 120 flood protection structures, such as ponds and ridges, particularly along Ouadi el Khechen and Tariq Tniet el Assal. The number of these structures has now reduced by half.
- Urban areas have seen the construction of local retaining walls along rivers. These are primarily for the structural integrity of the walls, not necessarily designed for flood mitigation.

Qaa:

- The Qaa region's flood protection structures are more diverse, encompassing gradoni terraces, hill lakes, ponds, and various stone bunds and walls. There were initially 66 such structures in the Qaa 1 watershed.
- The field visit underscores the vulnerability of flood protection structures in the face of repeated and severe flooding events. The degradation of these structures not only compromises their effectiveness but also poses a risk to the areas they are designed to protect. There is a need for the design and implementation of more durable and sustainable flood protection measures. Furthermore, the diversity of structures in Qaa suggests a more multifaceted approach to flood risk management, which may offer insights into more effective strategies that can be applied in similar contexts. Overall, the findings call for a reassessment of current flood protection strategies, the introduction of more resilient infrastructure, and perhaps a move towards nature-based solutions that can better withstand the challenges posed by climate change and extreme weather events.

Socio-economic and gender characteristics

Local communities/ethnic groups (including interactions with herders and tribal dynamics)

The large-scale displacement resulting from the Syrian crisis has led to a significant influx of refugees into areas such as Fekha, Ras Ba'albek, and Qaa, exacerbating tensions between host communities and the newcomers. The sudden increase in population, averaging a 30% rise due to Syrian families,

who typically consist of four members, has put a considerable strain on local infrastructure and altered the social dynamics within these communities (UNDP, 2018).

One of the primary sources of friction is the competition over natural resources, especially water. The increased demand for water, coupled with the livelihood pressures that both communities face, has heightened tensions. The situation is further complicated by the perception that international organizations are focusing their support on Syrian refugees while seemingly neglecting the needs of the Lebanese population, contributing to feelings of marginalization among the hosts. In some areas, measures such as imposing curfews on Syrian refugees have been taken, and economic tensions have been fueled by the practice of paying refugees lower wages than Lebanese workers, which is intended to reduce competition in the labor market but also perpetuates a sense of inequity.

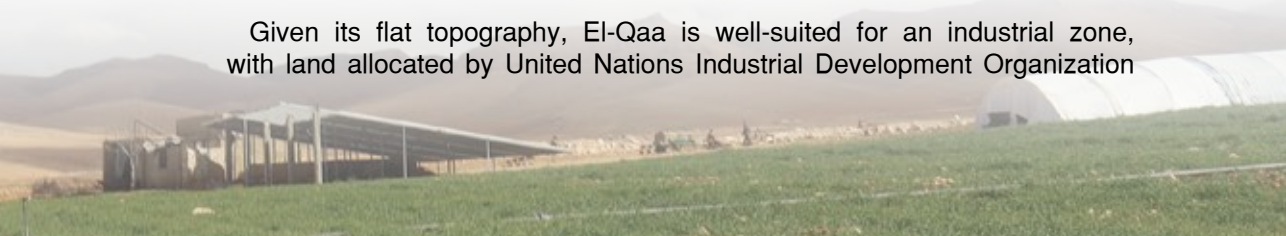
The mayor of Qaa's statement about linking aid to compensation for damaged crops is indicative of the growing frustration among local Lebanese communities. This sentiment reflects broader concerns over the allocation of resources and assistance. Waste management has also become a contentious issue, with the increase in waste generation due to the refugee influx overwhelming the existing waste disposal mechanisms. This has resulted in financial burdens on the municipalities, which struggle to manage the landfill capacities and the costs associated with waste disposal. The failure to address this issue collaboratively with refugee-support organizations has only added to the strain between the communities.

The challenge of water access is particularly acute, as the surge in population due to the refugee presence has led to higher water consumption, reliance on water trucking, and instances of illegal tapping into water sources. This competition over shared water resources poses a threat to sustainable development and risks perpetuating cycles of poverty, social instability, and further migration. Addressing these multifaceted issues requires comprehensive strategies that focus on resource management, equitable support distribution, and community engagement to foster social cohesion and sustainable development for both host communities and refugees.

Qaa

Qaa, situated in the Ba'albek–Hermel District and bordered by Syria, Hermel, and Ras Ba'albek, has a rich history rooted in honey production and a picturesque landscape. It was historically known for its natural lake, which was a trading hub. Religious sites attract religious tourists and foreign visitors. The village experiences a hot, semi-arid summer and cold winter due to its location between the anti-Lebanon mountain range and the Orient River. It's primarily inhabited by Greek Catholics. However, El-Qaa has faced challenges like desertification and water scarcity, impacting agriculture. The proliferation of random wells has exacerbated water scarcity, particularly during the summer, leading to a decline in agricultural projects over the past five years.

Given its flat topography, El-Qaa is well-suited for an industrial zone, with land allocated by United Nations Industrial Development Organization



(UNIDO) for industrial development, likely focusing on food processing. Its location along an international highway connecting Ba'albek to the Syrian border and proximity to Hermel further enhances its potential. Healthcare is served by centers like the Malta Organization Health Center and nearby hospitals in Hermel and Ba'albek. The education level has improved, with many youths holding university degrees. Syrian refugees, however, often leave school at 13 to support their families financially.

With a population of around 14,000, Al-Qaa's demographics include a median age of 29.6 for males and 26.8 for females (Table 8). The economic situation in the region is deteriorating, affected by the crisis and influx of displaced people from Syria and neighboring Lebanese areas. Al-Qaa could potentially host an industrial construction zone, serving as an entry point for Syria's reconstruction if the situation normalizes, creating job opportunities and attracting investment. Agriculture is a key livelihood, while women often work in schools and the public sector. Many Lebanese families are now below the poverty line due to economic crises and currency depreciation. However, remittances from abroad help support those remaining in Lebanon.

Table 8: Summary of Al-Qaa's main socio-economic characteristics (Data source: Localliban, 2017)

Population per village (registered resident, displaced)	14,000 registered – 33,000 Syrians, 5,500 residents – 7,500 displaced Lebanese
Number of hospitals/health centers/ health care index	Two health care centers. No hospitals
Age groups and gender	Syrians: the majority are young, and the percentage of females is around 60%. As for the Lebanese: females make 52%, and 50% are young men (no official statistics, these numbers are based on the election lists)
Education level, specialty, gender	5 schools (3 public and 2 private)
Professions in general	Public sector jobs - agriculture - free professions - as for Syrians working in food processing, agriculture, construction, and some self-employment
The main sources of income	Aid from the displaced and expatriates and agriculture, as for the Syrians from non-governmental organizations
Cultural practices associated with natural resources	The supply of dry fruits such as figs and grapes (raisins is increasing. The municipality and associations have a role in raising awareness about these practices.
Safety indicator	Not good because of the Syrians and sectarianism in this region (Christians have become a minority) and there is conflict over land and access to water
The ratio of real estate price to income	Low
Purchasing power	Low
Cost of living	High

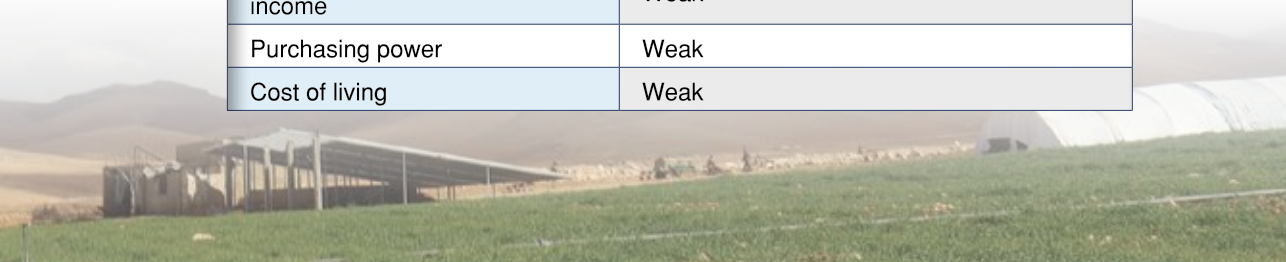
Ras Ba'albek

Ras Ba'albek is steeped in heritage and historical significance and is renowned for its caves with ancient monuments and carvings indicating human habitation dating back 14,000 years (Al-Tamayor cave). The population consists of approximately 15,000 registered individuals, of which only 2,000 are permanent residents. Many people, primarily living in Beirut, return to Ras Ba'albek for summer vacations. The population is predominantly Christian, specifically Roman Catholic, having transitioned from Orthodox Christianity in 1721. The median age is 28.2 years, with the male median age at 29.6 and the female median age at 26.8.

Social conditions in Ras Ba'albek are reported to be favorable, contrasting with the bleak economic circumstances that have resulted in displacement and migration to Beirut or beyond Lebanon (Table 9). The majority of residents are employed in the public sector or the Lebanese armed forces, particularly the Lebanese army. Women are active in the workforce, some engaging in Mouneh production as a livelihood, a traditional practice involving the preservation of various foods. Ras Ba'albek's specialty lies in the production of "Mouneh," including items like grapevine leaves stored in jars for specific Lebanese dishes, "Hosroum" juice extracted from green grapes as a winter substitute for lemon juice, pomegranate citric juice, tomato paste, pepper jam, dried fruits,

Table 9: Summary of Ras Ba'albek's main socio-economic characteristics (Data source: Localliban, 2017)

Population per village (registered, resident,displaced)	Registered 15,000 (based on KII with the mayor) 2,000 residents
Number of hospitals/health centers/health care index	Hospital - 3 clinics, including a military clinic
Age groups and gender	No official statistics but there is more men and women
Education level, specialty, gender	Most youth are seeking their Bachelor degrees
Professions in general	Employees in public sector
The main sources of income	60$ from public sector salaries
Cultural practices associated with natural resources	Food processing (Mouneh)
Safety indicator	Good
The ratio of real estate price to income	Weak
Purchasing power	Weak
Cost of living	Weak



jams, Makdous, Kishk, and thyme. While agriculture has improved, it remains small-scale and primarily geared toward fulfilling family needs.

The economic crisis in Ras Ba'albek has caused severe financial hardships, leading to reduced salaries of around 60$ per month. Residents are struggling to afford basic needs and have turned to home-based agriculture due to food affordability challenges. Syrian workers in the area have seen their wages cut to under 2$ per day, partly due to the support they receive from the United Nations. This has created tensions between Syrians and Lebanese hosts, as rumors of Syrians benefiting more from aid in U.S. dollars circulate. Lebanese workers also face difficulties due to the depreciating Lebanese pound. The resulting economic disparities contribute to existing tensions. Amid the worsening crisis, vulnerability among local Lebanese families is increasing.

Al-fakha

The village of Al-fakha is located in the northeastern part of Ba'albek Hermel Governorate, near the Ba'albek-Homs international road. It borders various towns and includes five villages. Education is significant in Al-fakha, hosting several public and private schools (a total of 8). There are no higher education institutions, and healthcare facilities are limited to clinics. The population of around 5,000 is a mix of Christians and Muslims, with a range of registered voters (Table 10).

There are about 2,800 buildings in Al-fekha, mainly residential. The average age is around 28.2 years. Livelihoods primarily come from public and private

Table 10: Summary of Al-fekha's main socio-economic characteristics (Data source: Localliban, 2017)

Population per village (registered, resident, displaced)	5000 registered and 1000 displaced Syrians
Number of hospitals/health centers/health care index	Three dispensaries
Age groups and gender	Average 40 years
Education level	University degree
Professions in general	Public sector and governmental jobs - liberal professions - agriculture
The main sources of income	Low (less than 100$) - state jobs
Cultural practices associated with natural resources	The production of Mouneh is high while the crafts like carpets are low
Safety indicator	Good
The ratio of real estate price to income	Low (previously good)
Purchasing power	Low
Cost of living	Low

jobs, free professions, trade, and agriculture. Roughly 50% of adults work in these sectors, while unemployment leads many young people to migrate or join the Lebanese army. The region, like neighboring villages, faces widespread poverty due to Lebanon's prolonged economic crisis. The crisis has pushed over 80% of the population into poverty, leading to reduced salaries and increased prices of essential goods.

Local political economy and employment (with a focus on the role of water/agriculture)

Lebanon's current situation is marked by a severe socio-economic crisis resulting from mounting public debt and fiscal deficits. The crisis is driven by factors such as the devaluation of the Lebanese pound, rising unemployment and poverty, business closures, inflation, limited access to foreign exchange and imports, and decreased foreign remittances. The economic hardship disproportionately affects vulnerable Lebanese and refugee populations, leading to failing public services, increased unemployment, and depleted human capital due to emigration. The private sector suffers due to a paralyzed financial system, causing layoffs and bankruptcies.

Amidst this dire humanitarian and economic situation, Lebanon is grappling with a political deadlock marked by accusations of corruption and a sense of impunity. Political divisions have resurfaced after being momentarily overshadowed by socioeconomic protests in October. The country entered an unprecedented government crisis in November 2022, with no president, a limited-power caretaker cabinet, and a fragmented parliament.

The Lebanese economy faces a triple crisis: an ongoing economic and financial crisis since 2019, the impact of the COVID19- pandemic, and the repercussions of the August 4th Beirut port explosion. The financial crisis, driven by years of deficits, increasing debt, and delayed structural reforms, has been the most detrimental. The economy contracted by nearly 20% in 2020, with key sectors like tourism and construction severely affected.

The economic crisis has contributed to a surge in poverty, with an 82% poverty rate in 2021, up from 45% in 2019 (UN-ESCWA, 2022). Vulnerable households struggle to access necessities, and the unemployment rate rose to 30% in 2022 from 11% in 2019. The crisis hits hardest in certain regions like Akkar and Ba'albek-Hermel (ILO, 2022).

Lebanon's social fabric is strained, with around four million people needing humanitarian assistance, including 1.5 million displaced Syrians and 2.2 million vulnerable Lebanese. Syrian refugees face dire circumstances, worsened by the COVID-19 pandemic and the Beirut port explosion in August 2020. The Bekaa Valley, hosting a significant refugee population, is particularly affected by the Syrian crisis (EU, 2023).

Ba'albek-Hermel, a governorate in Lebanon, encompasses the Ba'albek

and Hermel districts with a population of approximately 416,427. The area, predominantly Shiite with pockets of Christians and Sunnis, hosts a substantial number of Syrian and Palestinian refugees. The governorate, already the poorest in Lebanon, has faced additional strain due to the influx of Syrian refugees, impacting infrastructure and services. The governorate also experienced security challenges due to violence spillover from Syria, affecting areas like Arsal and Ras Ba'albek.

The Lebanese authorities have taken measures to address security concerns, with a strong presence across the region. Security forces have been involved in deterring extremism and evicting individuals from informal settlements near military facilities and supply routes.

Labor market and unemployment characteristics

Official unemployment statistics for Ras Ba'albek, Qaa, and Fek-ha villages are unavailable. However, a study by the Central Administration of Statistics (CAS) in collaboration with the International Labour Organization (ILO) shows that national unemployment rates in Lebanon have significantly risen. The overall unemployment rate increased from 11.4% in 2018-2019 to 29.6% in January 2022. For youth aged 15-24, the unemployment rate surged from 23.3% to 47.8% during the same period (ILO, 2022).

At the governorate level, unemployment rates rose across all regions, with Ba'albek-Hermel experiencing the most substantial increase. The unemployment rate there surged by 30 percentage points, reaching 40.7% in January 2022, up from 11% in 2018-2019 (ILO, 2022).

Moreover, a considerable portion of Lebanese youth, particularly females, were not engaged in employment, education, or training (NEET). In January 2022, around 32.1% of young women were NEET, up from 26.8% in 2018-2019. A similar trend was observed among young men, with the NEET rate increasing from 16.7% to 26.1% during the same period (ILO, 2022).

The NEET rates were higher among females in most governorates, except for Beirut and Bekaa. The highest rates were in Akkar (48.6%) and North Lebanon (37.7%) for females, while Beirut (35.2%) and Bekaa (32.5%) recorded the highest male NEET rates (ILO, 2022).

Impact of the socio-economic crisis on the rural areas and agriculture sector

The socio-economic crisis in Lebanon has particularly dire implications for rural areas and the agriculture sector. While agricultural labor makes up less than 10% of the overall labor force (ILO, 2022), around a quarter of rural workers depend on agriculture (WorldBank, 2018). The decline in agricultural production puts rural livelihoods at risk, especially in regions like Akkar and Bekaa. Syrian refugee workers, a significant portion of whom are employed in agriculture, also face increased unemployment. The crises have caused a

notable rise in food insecurity, with about 20% of the population consuming inadequate diets and 40% of households experiencing difficulty covering food expenses in 2020 (WFP, 2020).

Despite the challenges, opportunities for agricultural development exist. Certain products, such as tomatoes and potatoes, possess a competitive edge in international markets and could thrive with improved quality compliance and marketing strategies. The devaluation of the Lebanese lira and the higher cost of imports could incentivize the production of essential crops like wheat. However, the political ban imposed by Saudi Arabia on Lebanese fruit and vegetable imports has significantly impacted the agricultural sector, given that Gulf countries are major markets for these goods (USAID, 2020).

Food insecurity rising as the economic environment worsens

The economic hardships in Lebanon have exacerbated the situation, leading to rising unemployment, poverty, and inflation rates. The World Bank reports a significant decline in the country's GDP from USD 55 billion in 2018 to an estimated USD 20.5 billion in 2021, with a 37.1 percent drop in real GDP per capita.

Rural areas, like Northern Ba'albek, have borne the brunt of neglect from the government over decades. These regions, relying heavily on agriculture, have seen livelihood opportunities vanish due to soaring prices, fuel costs, and the devaluation of the Lebanese pound. This has pushed many to leave their rural lands in search of employment in urban areas.

In places such as Ras Ba'albek, Qaa, and Fekha villages, food insecurity is prevalent. People have turned to planting their fruits and vegetables due to unaffordable market prices. Many rely on local seasonal agriculture, adopting more vegetarian diets due to the high cost of meat.

While vegetable and cereal production remain essential income sources for rural communities, economic stability and food security challenges persist. Tomatoes are particularly important as a staple food and income source, with export potential. Similarly, wheat and barley play crucial roles in crop rotation and food provision, with their straw supporting household livestock. However, increased costs of seeds and pesticides have forced many small farmers to abandon their lands for urban areas in search of better opportunities.

Household access to water/energy, food security, debt, finance, and access to the market (focus on farming households including women, youth, and vulnerable people)

Changes in water consumption over the past decade

Over the past decade, changes in water consumption have been influenced by the rapidly worsening economic crisis. Shortages of funding, fuel, and essential supplies like chlorine and spare parts have led to a gradual reduction

in water pumping across various regions in Lebanon. The economic crisis has severely impacted the water sector, leading to its inability to function effectively due to high maintenance costs in dollars, water loss from non-revenue sources, the simultaneous collapse of the power grid, and the looming threat of increased fuel prices. The potential loss of access to the public water supply places households in a difficult position, forcing them to make tough decisions about meeting their fundamental water, sanitation, and hygiene needs (UNICEF, 2021).

Impact of refugees on land, water, and sanitation management

The influx of Syrian refugees in Lebanon's Northern Bekaa region has strained resources, impacting land, water, and sanitation. Informal settlements and urban sprawl have led to agricultural land loss and ecological disruption. Water demand from refugees has caused groundwater overexploitation, lowering levels and quality. Sanitation issues and waste mismanagement have spread diseases. UNHCR and NGOs collaborate with the Lebanese government and local communities to address challenges (Al-Sayah, Sarkissian, & Abdallah, 2022). Initiatives include efficient water use, infrastructure development, sanitation improvement, waste management enhancement, and WASH projects. These efforts aim to safeguard health, resources, and the environment amidst the refugee crisis.

key findings of FGDs and KII done throughout the project

Throughout the assessment, two focus group discussions (FGDs), each group with 8-10 women participants, and 3– 4 key informant interviews (KIIs') with women were done. Below are key points that were extracted from the FGD and KII:

- The main work done by women in rural Lebanon is producing traditional foods like kishek, jams, pickles, dried fruits, and mouneh. Additionally, New farming practices and products are introduced, including soap, creams, saffron, lavender, and oregano. However, their implementation is still somewhat limited.
- Men used to work in the army or teach at schools, and nowadays, they work in the NGO sector or they invest in agricultural projects.
- Typically, in agriculture, men labor in farming, whereas women work in post-harvest operations such as food production.
- Farmers hardly ever utilize social media, which hinders their capacity to establish relationships with other markets. They rather rely on their connections locally or in Beirut and the visitors of the area.
- Women typically produce goods on their own or through women's organizations in Ras Baalbeck and Qaa.
- The women's association in Ras Baalbeck was funded and equipped by John Paul II, and they received training from FAO; they have their label, "Zowedeh".

Agricultural characteristics

Farming, cropping, and production systems typology

North Bekaa, a region with a rich history of agricultural practice dating back to Roman times and possibly earlier, continues to rely heavily on agriculture in the present day. Rainfed fruit trees and irrigated agriculture constitute a quarter of the total study area, showcasing the significance of agricultural activities in the region. However, the landscape is dominated by bare rocks, accounting for nearly half of the area, while forested regions suffer from ongoing degradation, primarily due to uncontrolled overgrazing, as can be seen in Table 4. Water scarcity is a critical issue in this region, much like in the Hermel area, posing a significant constraint to agricultural productivity. The challenge is compounded by the threat of secondary salinization, which affects soil health and crop yields. To combat these issues and conserve precious water resources, the implementation of well-managed drip irrigation systems is recommended. These systems are known for their efficiency in water usage, making them a suitable option for sustainable agriculture in water-deficient areas.

The conflict in July 2006 had a profound impact on North Bekaa, leading to the widespread destruction of infrastructure, biodiversity, and agricultural land. The war caused substantial damage to crops, either through direct bombing or because they could not be harvested or sold. The destruction extended to public irrigation systems and resulted in the loss of livestock, either due to direct attacks or as a consequence of starvation and dehydration. The post-conflict period has seen heightened security risks that have halted forest management activities. Additionally, fuel shortages have driven locals to fell trees for firewood, further depleting the region's forests and woodlands. The loss of biodiversity from such destruction is significant and difficult to quantify (UNDP, 2013).

In contemporary times, the Baalbeck – Hermel area in North Bekaa is grappling with a multitude of environmental challenges. Drought conditions, low agricultural productivity, biodiversity loss, and flooding issues are prevalent. The flooding is exacerbated by surface runoff during heavy rains, poor soil infiltration, and degraded vegetation cover, which diminishes the soil's ability to absorb water effectively. Addressing these complex issues requires a multifaceted approach, including the adoption of sustainable agricultural practices, effective water management strategies, reforestation efforts, and improved land management to prevent further degradation and promote resilience against climate-related extremes (USAID, 2019).

Farming skills, integration, and diversification

Agriculture and major farming activities

In the North Bekaa region, there's historical evidence of irrigation dating back to Roman times, as seen through ruins of temples, canals, and tunnels showcasing advanced engineering and hydraulic structures. The area once held the title of the "Grainery of the East" in Roman history. Over time, due to invasions, changing populations, and potential earthquakes, these ancient irrigation systems have deteriorated and are now primarily of archaeological significance.

Although irrigation is still practiced, its efficiency has diminished, leaving much of the good land underutilized. Notably, the decline in efficient irrigation is evident north of the village of Qaa, primarily due to water scarcity. Around 2,000 hectares of land, suitable for irrigation, are now dry-farmed. Some of these lands were once irrigated by water from the Nahr el Assi, as indicated by the remains of an ancient underground conduit. However, after the year 2000, farmers began drilling private wells, leading to the expansion of agricultural areas to nearly 5,000 hectares between Ras Baalbeck and Qaa (Figure 9).

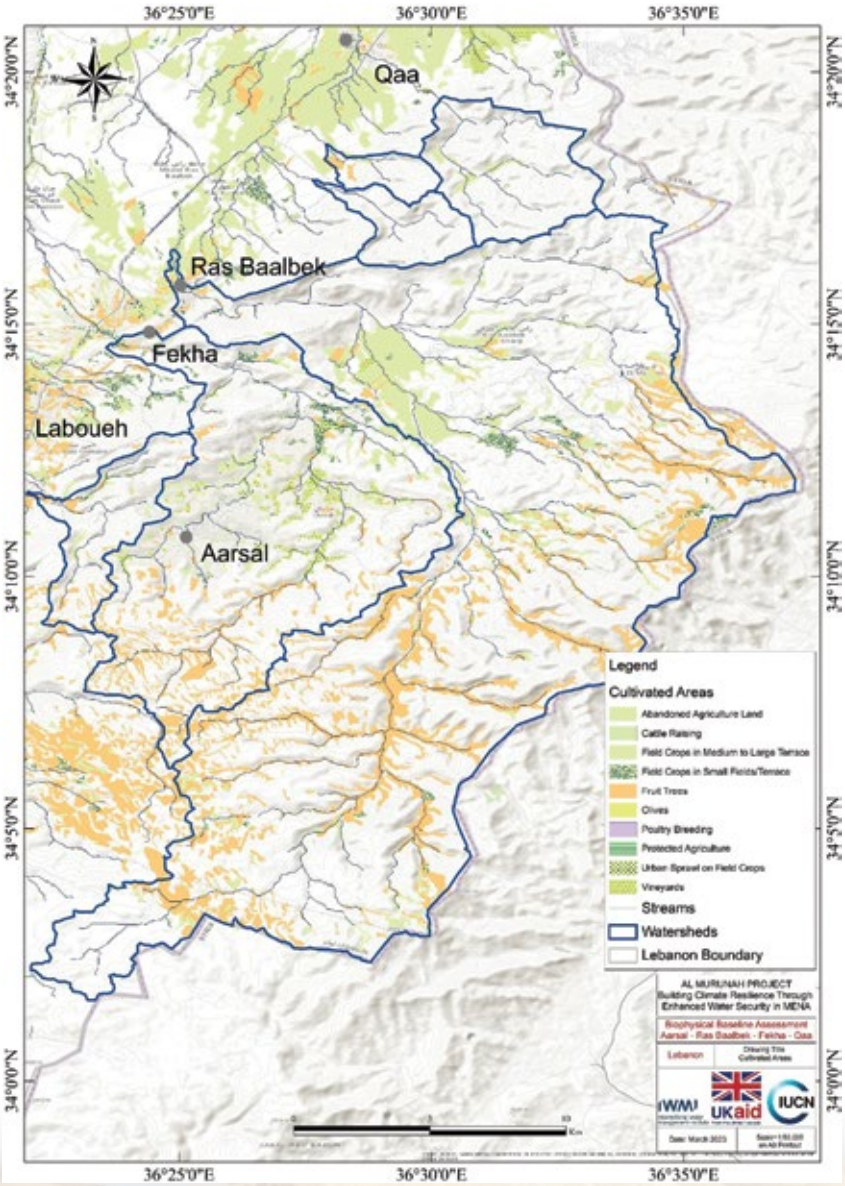


Figure 9: Cultivated areas within the study area (Data source: CNRS, 2018)

These irrigated lands have the potential to yield a variety of climatically suitable crops at a reasonable cost. The recent expansion of agricultural areas through private well drilling indicates the revival of farming practices, but efficient water management remains crucial for sustainable productivity.

Water use efficiency, and productivity

A considerable amount of land above Bekaa Plain is being irrigated, however, no irrigation scheme has been defined yet. The water comes from springs located in the narrow valleys formed by faulting and erosion. The areas irrigated are generally small, and non-continuous. And have varying amounts of water available; most have only a partial water supply. They are served generally by small canals that are poorly constructed. Water use efficiency is low and canal losses are high. No attempt at regulation is made, even though reduced quantities of water may be required for irrigation or other uses. This results in a sizeable waste since only a portion of the water wasted from the canals returns to the streams for use downstream (BWE, 2019).

Status of the technical advisory services, investment by the private/ public sector, and donors

Several previous projects were implemented in that scope of area in the last few years. For example, the Ministry of Agriculture in Lebanon has actively engaged in the implementation of NbS and green projects. For instance, they have successfully executed initiatives that involved cultivating tree seedlings within their nurseries that were subsequently employed in reforestation efforts, effectively mitigating the adverse effects of floods, preventing soil erosion, and bolstering the overall vegetation and pastoral coverage. They have also been part of the implementation of interventions in the Al Murunah project area, such as Ras Baalbeck, Qaa, and Fekha. The primary objective of these interventions was to mitigate flood impacts and safeguard crucial elements like the Al Assi River, fishponds, agricultural lands, and human settlements using a diverse range of strategies, including the implementation of gabions, the creation of water-collecting ponds, groundwater replenishment, and innovative water harvesting techniques. These flood management endeavors were funded by international organizations such as GTZ and UNDP.

Institutional and policy analysis: National water and agricultural policies and their relationship to RNBWS

Overview of NbS and AWM approaches for food mitigation and management

Nature-based Solutions (NbS) and Agricultural Water Management (AWM) are approaches that can help mitigate and manage flash floods in semi-arid rural areas. NBS involves using natural systems to address challenges, such as absorbing water and improving ecosystem resilience. AWM focuses on

conserving water resources in agriculture and enhancing soil moisture and crop productivity.

Examples of NbS/AWM for flash flood mitigation:

- Rainwater harvesting in reservoirs to reduce runoff.
- Water retention structures like check dams and ponds to slow water flow.
- Sustainable land use practices to reduce erosion and improve soil water absorption.
- Vegetation management to prevent erosion and promote water absorption.
- Micro-irrigation systems to conserve water.
- Crop rotation and soil conservation measures to enhance soil health and water absorption.
- Soil moisture conservation techniques like mulching and cover cropping.
- Combining NbS and AWM approaches for comprehensive flood management.

In the North Bekaa region, water harvesting, and efficient irrigation can supplement scarce water resources and support rainfed crops during dry seasons, improving agricultural productivity and farmers' income. These approaches contribute to sustainable flood mitigation while promoting resilient agriculture.

Assessment of the effectiveness of NbS and AWM for flood mitigation and management in the study area

The assessment of NbS and AWM effectiveness for flood mitigation reveals that existing structures have deteriorated due to a lack of maintenance and successive floods. Initial success waned over time, particularly after the 2014 flood. The uneven distribution of structures also hampers their efficiency. Recommendations include regular maintenance, adaptive design, comprehensive distribution, community involvement, and monitoring. Implementing these steps can enhance NbS and AWM efficacy, improving flood management in the study area.

Recommendations

Identified gaps

Identified gaps in the flood assessment and management approach for the study area include:

1. Lack of detailed flood hazard and risk assessment: The existing report offers a general overview of the flood history and previous studies but lacks a comprehensive assessment of flood hazard and risk. This assessment needs to focus on secondary streams in the upper region, considering factors contributing to flash floods and desertification, and

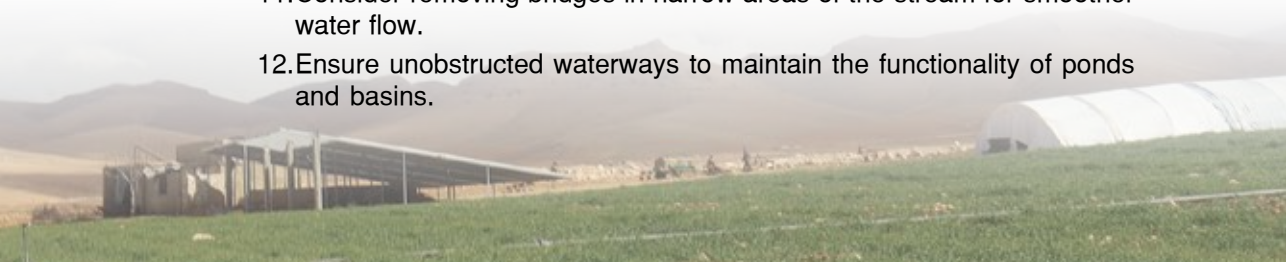
evaluating the frequency, magnitude, and extent of floods.

2. Incomplete information on existing flood protection structures: While various flood protection structures have been implemented, their effectiveness in reducing flood risk and damage remains unclear. A thorough assessment is required, involving site visits, detailed design comparisons, geotechnical evaluations, and topographical surveys to determine if modifications, repairs, or replacements are necessary.
3. Lack of hydrological data: accurate and up-to-date hydrological data are essential for designing effective NbS and AWM interventions. This data should include information about flood frequency, intensity, and other relevant parameters to inform mitigation strategies.
4. Lack of community involvement and participation: The current report does not address community engagement or awareness regarding flood management. Involving local communities in the planning and implementation of NbS and AWM initiatives is crucial for ensuring the sustainability and success of flood mitigation efforts.

Recommendations for detailed intervention

The recommendations for detailed interventions in NbS and AWM for flood risk management in the study area include:

1. Repair and expand retention ponds and structures based on flood risk assessment.
2. Implement regular maintenance of retention ponds to prevent damage and flooding.
3. Clean and divert water from the mainstream to prevent debris accumulation and overflow.
4. Manage water levels in retention ponds through controlled inflow and outflow.
5. Conduct frequent field visits to assess and maintain basins and sewers.
6. Preserve vegetation cover and undertake afforestation campaigns along stream edges.
7. Restore natural floodplains and create riparian buffer zones for floodwater storage.
8. Afforest and reforest stream banks to reduce surface runoff and erosion.
9. Establish a rainfall monitoring system and early warning system with weather stations.
10. Develop a strong storm action plan for effective flood management.
11. Consider removing bridges in narrow areas of the stream for smoother water flow.
12. Ensure unobstructed waterways to maintain the functionality of ponds and basins.



These recommendations aim to enhance flood risk management by combining NbS and AWM strategies, ultimately reducing flood risks and improving community resilience.

National-level institutions at the core of the water/agriculture nexus

Link to National Strategies, the Ministry of Energy and Water (MEW) has recently prepared the Updated National Water Sector Strategy NWSS 2020 - 2035 by setting a detailed action plan to implement reforms, create a hydrogeological data management system, and improve service coverage. It considers the adopted Water Code (law 192/2020) and its structuring principles. The newly ratified Water Code includes several Integrated Water Resources Management (IWRM) implementation principles and aims to regulate, develop, rationalize, and exploit water resources, protect them from depletion and pollution, and improve the efficiency of transport, distribution, and maintenance systems for the operation of water installations to ensure the sustainable management of the Lebanese natural water resources. As per the water code, the MEW aims at achieving a financially sustainable sector, that is citizen-centered and service-oriented, which would ultimately allow to reach an integrated approach of the water sector. The updated strategy can be considered as a shift into practical, implementable plans, projects, and governance initiatives that set the ground to move toward the UN's Sustainable Development Goal SDG 6 and realize the principles of an IWRM. While doing so, the updated NWSS 2020 targets as well as SDG 2 (zero hunger), SDG 7 (affordable and clean energy), SDG 13 (climate action), SDG 14 (life below water), SDG 15 (life on land) and SDG 17 (partnerships for goals); Based on the United Nations' SDG 6, the MoEW aims at providing safe, equitable and affordable water and wastewater services to all, and to properly allocate the water resources to the different economic sectors (agriculture, industry, tourism, services, etc.) based on the priorities of the government's recovery plan.

These commitments are translated by strengthening the IWRM through targeted proposed projects and improved governance at the basin level, mainly:

- Implementing an integrated hydrological information system (IHIS) that would act as a strategic tool for decision-making in the water sector. Decisions on IWRM, flood and drought management, locations and feasibility of dams, groundwater extraction, rainwater harvesting, and water allocation among economic sectors can only be made in light of data availability, reliability, and proper analysis.

- Putting in place management plans for disasters related to the water sector such as floods, drought, and forest fires that require the Ministry's intervention and preparation.

- Relying on nonconventional resources to fill the deficit gap of the water balance where possible and ensure sustainable sector management, like artificial aquifer recharge, wastewater reuse, and rainwater harvesting.
- Improving the service coverage to fill the gaps between what has been implemented and what remains to be executed to cover the needs of the population in terms of potable water supply, wastewater collection, and water for irrigation. The MoA has also prepared its NAS for 2020-2025 which aims to transform the agricultural sector in Lebanon into a more productive and profitable industry, ultimately reducing the country's food import bill. The NAS, provided with the agreed priorities and related set of interventions, represents the operational instrument through which the agrifood sector can contribute to absorbing the crises-induced economic shocks as well as to recovering the Lebanese economy. The NAS's long-term vision is to make the agrifood system a main contributor to the achievement of food security and a key driver of resilience and transformation of the Lebanese economy into a productive economy.

The NAS's overall objective is to transform the Lebanese agri-food system into a more resilient, inclusive, competitive, and sustainable agrifood system.

The NAS core structure is composed of five strategic axes (pillars):

- **Pillar 1:** Restoring the livelihoods and productive capacities of farmers and producers
- **Pillar 2:** Increasing agricultural production and productivity
- **Pillar 3:** Enhancing efficiency and competitiveness of agrifood value chains
- **Pillar 4:** Improving climate change adaptation and sustainable management of agrifood systems and natural resources
- **Pillar 5:** Strengthening the enabling institutional environment

Conclusion

In conclusion, the baseline assessment for the project areas (AlQaa, Ras Baalbeck, and Fekha) showed a demand for strategic interventions. The assessment has underscored the pressing need for rehabilitation of the deteriorated structures and fostering community participation. Challenges prevail, such as the lack of detailed flood hazard assessments, incomplete information on existing flood protection structures, and the absence of some hydrological data. Moreover, the aftermath of the 2014 flood, coupled with the challenges available, underscores the vulnerability of the region to recurring flood events.

Addressing the identified gaps mandates some recommendations that span from repairing and expanding retention ponds, cleaning waterways, implementing flood hazard assessments, and community involvement. Those identified challenges allowed planning and justifying the planned interventions in alignment with national priorities and policies through a focus on Nature-based Solutions, sustainable water management, agriculture water management, and community empowerment. Importantly, these interventions act as testing grounds for scalable solutions that can be adapted and replicated in similar contexts, contributing to broader national activities.

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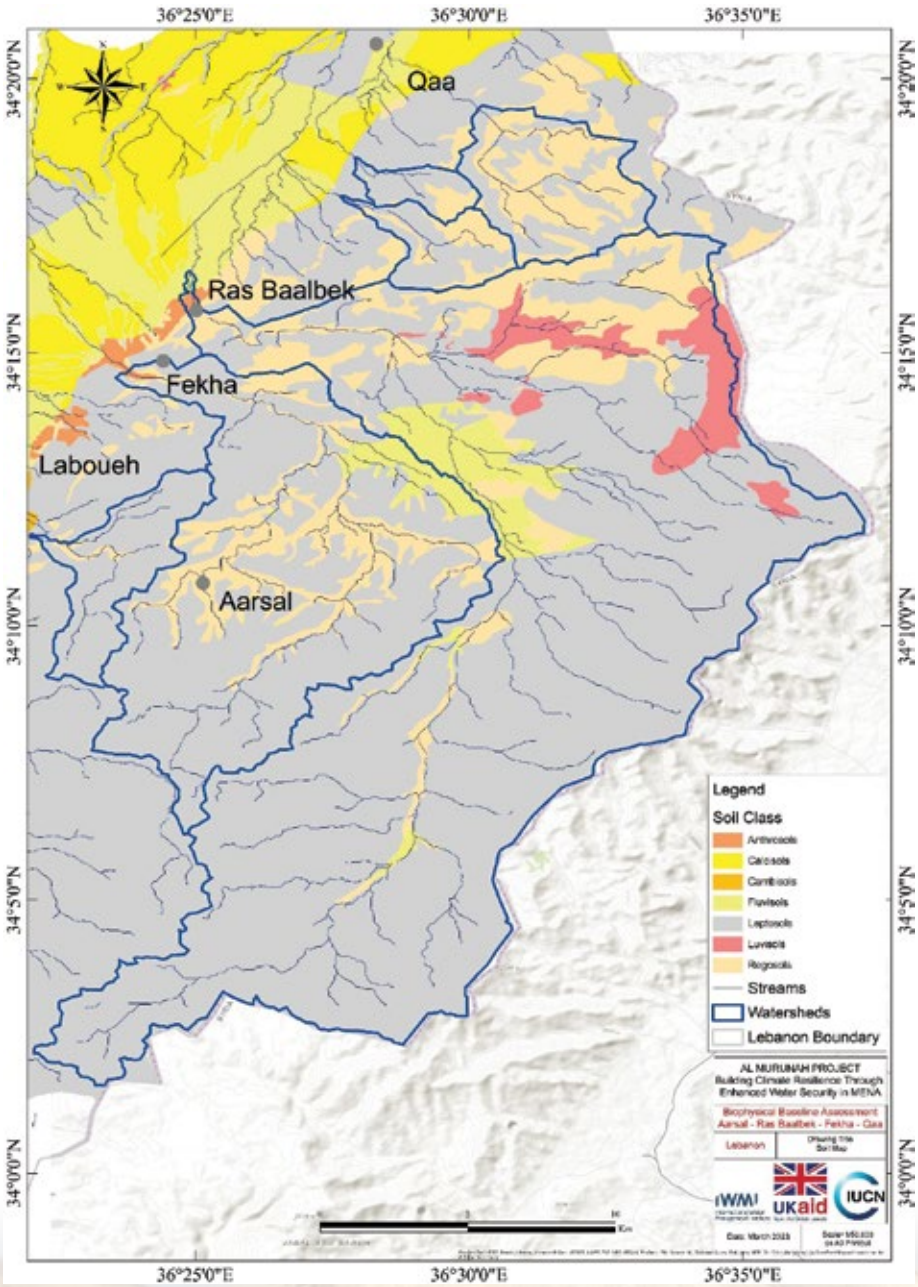
Appendices

Annex 1: Soil map of the study area (adapted from: Darwich & NCSR, 2006)



Annex 2: Distribution of soil classes and groups in the study area (adapted from: Darwich & LNCSR, 2006)

Soil Class (Higher and Lower)	Area (km²)	Ratio (%)
Leptosols	586	**59.9%**
Aridic and shallow Leptosols	428	43.7%
Non calcareous and gravely Leptosols	84	8.6%
Calcareous Leptosols	74	7.6%
Regosols	137	**14.0%**
Calcareous Regosols	97	9.9%
Xeric Regosols	39	4.0%
Non calcareous Regosols	1	0.1%
Calcisols	134	**13.7%**
Calcisols with a cemented layer	128	13.1%
Shallow Calcisols	5	0.5%
Clay Calcisols	1	0.1%
Fluvisols	70	**7.1%**
Association of Aridic and Calcaric Fluvisols	70	7.1%
Cambisols	33	**3.4%**
Non calcareous clay Cambisols	22	2.3%
Calcareous clay Cambisols	11	1.1%
Luvisols	15	**1.5%**
Non calcareous clay Luvisols	15	1.5%
Anthrosols	4	**0.4%**
Non calcareous, clay anthrosols	4	0.4%

INTERNATIONAL UNION

FOR CONSERVATION OF NATURE

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