The Pearl

REPORT

Protecting Lebanon's forests to enhance local economies, build resilience to climate change and support peacebuilding

Technical Report - Phase I: Analysis and Planning

Prepared by

The Pearl (formerly the Walker Institute), University of Reading

in collaboration with

The Lebanon Reforestation Initiative (LRI) and **The Royal Scientific Society of Jordan (RSS)**

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Disclaimer

TABLE OF CONTENTS

LIST OF FIGURES

LIST OF TABLES

ACRONYMS AND ABBREVIATIONS

ACRONYM AND ABBREVIATION	DEFINITION
AKKAR	Akkar Governorate, northern Lebanon
CEDA	Centre for Environmental Data Analysis
CMIP6	Coupled Model Intercomparison Project Phase 6
DEM	Digital Elevation Model
ECMWF	European Centre for Medium-Range Weather Forecasts
ERA5	Fifth Generation ECMWF Atmospheric Reanalysis dataset
EU	European Union
FGD	Focus Group Discussion
GCM	Global Climate Model
ICECCAP	Implementation Centric Evolving Climate Change Adaptation Process
ICICLE	Inclusive Consultative Integrated Climate, Livelihoods and Environment (storylines)
KII	Key Informant Interview
KPI	Key Performance Indicator
LARI	Lebanese Agricultural Research Institute
LHZ	Livelihood Zone i.e., an agro-ecological-economic area in which households have access to similar economic opportunities
LRI	Lebanon Reforestation Initiative
MCR	My Climate Risk (WCRP Lighthouse Activity)
MEL	Monitoring, Evaluation and Learning
MoA	Ministry of Agriculture (Lebanon)
MoE	Ministry of Environment (Lebanon)
MoEW	Ministry of Energy and Water (Lebanon)
NbS	Nature-based Solutions
NAP	National Adaptation Plan
NDC	Nationally Determined Contributions (under the Paris Agreement)
NGO	Non-Governmental Organisation
RSS	Royal Scientific Society (Jordan)
SSFA	Small-Scale Funding Agreement
UNEP	United Nations Environment Programme
WCRP	World Climate Research Programme
THE PEARL	People and Place: Evidence-based Adaptation for Resilient Livelihoods, University of Reading
THE WALKER INSTITUTE	Interdisciplinary climate research institute formerly at the University of Reading, superseded by *The Pearl*

EXECUTIVE SUMMARY

This report summarises the results of the first phase of the project "Protecting Lebanon's forests to enhance local economies, build resilience to climate change and support peacebuilding", implemented by the Lebanon Reforestation Initiative (LRI) under contract to the United Nations Environment Programme (UNEP) with analytical and methodological support from The Pearl (formerly Walker Institute) at the University of Reading, and regional insights from the Royal Scientific Society of Jordan. The project forms part of the EU-UNEP Climate Change, Environment and Security Partnership.

The work focuses on the Akkar governorate in northern Lebanon, where climate stress, ecological degradation and political fragility intersect, and where the resilience of livelihoods and natural ecosystems are deeply linked to social stability.

Purpose and approach

The project is designed to understand how people, place and environment interact under growing climate pressure, and to use that understanding to guide community-based adaptation. Phase I combines quantitative climate analysis with qualitative evidence from community consultations, key-informant interviews and a two-day participatory workshop held in Akkar. Scientific analysis of past and future climate conditions was undertaken through The Pearl's My Climate Risk science processes and ICICLE framework, integrating high-resolution climate data, livelihood zoning, and participatory mapping. The process placed local experience at the centre, the essence of "My" Climate Risk, testing how scientific evidence can be translated into practical decisions when time and capacity are limited, and when collaboration itself contributes to conflict prevention and peacebuilding.

Understanding change

Lebanon's climate has warmed significantly over recent decades. ERA5 reanalysis and local observation confirm longer, hotter summers, more erratic rainfall and a growing frequency of drought and flash-flood events. In Akkar, farmers and shepherds report the loss of predictable seasons, declining yields and soil degradation. These local testimonies correspond closely with modelled trends, giving empirical confidence that communities are already experiencing the leading edge of projected change. Statistically downscaled and bias-corrected CMIP6 model ensembles for the region show a clear signal of warming under all scenarios and an uncertain but increasingly variable rainfall pattern. Cluster analysis produced three coherent climate storylines (CS) for mid-century.

CS1: Hotter + Wetter - heavier rainfall events during the cool season increase flood and disease risk but may enhance groundwater recharge in well-managed catchments;

CS2: Hotter + Irregular Rainfall - alternating wet and dry periods within the same season, leading to unpredictable planting calendars and greater risks from pests and diseases;

CS3: Warmer + Drier - prolonged dry seasons reduce water availability and accelerate loss of soil moisture and vegetation decline.

Each storyline was linked to the livelihoods most at risk, forming the evidence base for locally-appropriate adaptation choices.

The process also underscored the importance of participation, trust and inclusion. In Akkar's mixed communities, bringing women, youth and smaller producers into the discussion helped surface practical barriers to adoption of new practices and improved the legitimacy of the chosen measures. Working with local leaders and civil society partners built confidence in how priorities were set and how trade-offs were handled, reducing the risk of tensions over scarce resources.

Community priorities and adaptation options

Across seven municipalities in the Union of Jerd el Kayteh, **Bzal, Dinbou, Hrar, Michmich, Qabaait, Sfaynet el Qaitaa and Habchit**, communities identified agriculture, water management and forestry as their principal climate-sensitive sectors. Livelihood-zone mapping distinguished urban, agricultural, natural and mixed zones, allowing discussion of risks and opportunities at a fine spatial scale. Using agreed criteria for feasibility, conflict-

sensitivity and alignment with nature-based-solution (NbS) principles, partners (LRI with support from The Pearl and UNEP) collectively ranked over forty potential interventions. The highest-scoring actions focused on water harvesting and storage, soil-and-slope protection, improved irrigation efficiency, fire-risk reduction and the restoration of degraded forest and agricultural land. These measures, refined through field feasibility visits, now form a practical portfolio of community-led adaptation interventions ready for implementation in the next project phase.

Innovations and lessons learned

The Akkar work demonstrates that rigorous, evidence-based adaptation planning is possible even in fragile and time-constrained settings when scientific and local knowledge are combined from the outset.

Key methodological advances include:

- **Rapid ICICLE process** - parallel rather than sequential analysis of climate data, livelihoods, and stakeholder input, enabling robust results within short project windows.
- **Hybrid livelihood-zoning approach** - combining remote-sensing analysis with participatory validation to generate trusted, conflict-sensitive maps.
- **Interdisciplinary working improved results** - having social scientists and a peace and security specialist working alongside climate and environmental analysts strengthened contextual understanding and conflict-sensitive design.
- **Integrated climate-livelihood storylines** - linking physical climate change to real livelihood narratives that communities recognise and can act on.

Operationally, the project highlighted the importance of interdisciplinary and multi-sectoral working. The Pearl's climate scientists and social science researchers worked alongside LRI's implementation team, a peace and security expert and local partners from multiple sectors, ensuring that environmental, livelihood and governance perspectives were connected from the start. This collaboration between scientific and operational communities was central to the project's success, demonstrating that adaptation planning benefits from trusted in-country leadership as much as from technical expertise. Flexibility in coordination, early contextual familiarisation and continued investment in relationship-building among municipalities and community leaders proved equally vital. These insights are informing design of the forthcoming implementation phase and are relevant to other crisis-affected contexts across the region.

Next steps

Phase II of the project (October 2025 to September 2026) will translate these analytical findings into tangible action. Activities will include the development of a local adaptation strategy for the agricultural sector in Akkar, farmer training and demonstration of resilient practices, implementation of one or more water-related interventions using NbS, and scenario stress-testing of options under mid-century climate conditions. The strategy will align with Lebanon's National Adaptation Plan and involve the Ministries of Agriculture, Environment, and Energy and Water, ensuring coherence between local practice and national policy. Lessons from Akkar will also feed into regional cooperation efforts under UNEP's transboundary adaptation and peacebuilding initiatives.

Looking ahead

The Akkar case study shows that adaptation planning rooted in local realities can build both ecological and social resilience. It underscores how participatory science can bridge the divide between national policy and community experience, and how local adaptation can contribute to stability and peace when designed with sensitivity to context. The findings and lessons presented here will inform the regional workshop on transboundary cooperation for adaptation and nature-based solutions in November 2025, providing a platform to share approaches and methodologies emerging from Lebanon with neighbouring countries facing similar challenges.

Acknowledgements

This work was made possible through the collaboration of many individuals and organisations. The Lebanon Reforestation Initiative (LRI) was contracted by the United Nations Environment Programme (UNEP) to lead implementation on the ground, with the active engagement of the seven municipalities of the Union of Jerd El Kayteh in Akkar. As an established and trusted national partner, LRI played a central role in linking science with local implementation and in bringing together governmental, community and sectoral partners across the region. Their leadership and close relationships within Akkar were essential to the project's success.

The Pearl (formerly the Walker Institute) at the University of Reading contributed through a UNEP Small-Scale Funding Agreement (SSFA) under the wider transboundary adaptation and peacebuilding project, providing analytical and methodological support that positioned the Akkar work as an exemplar case study for regional learning. The Royal Scientific Society of Jordan joined the team during the early analytical and planning phase, contributing regional insights and sharing experience from similar adaptation initiatives across the Middle East. The project was carried out under the EU-UNEP Climate Change, Environment and Security Partnership, with valued direction and encouragement from the UNEP West Asia Office.

We are very grateful to the many farmers, shepherds, community representatives and municipal leaders who took part in the focus groups, interviews and workshops, and who shared their experience of climate change and local adaptation. Their insights grounded the scientific analysis in reality and shaped the recommendations set out in this report.

Special thanks are extended to the interdisciplinary project team whose expertise and collaboration made this work possible. The Pearl's climate scientists and social researchers worked alongside LRI's field specialists and a peace and security expert, demonstrating how integrated approaches can connect environmental resilience with social stability through practical action.

Finally, we acknowledge the contribution of local partners and volunteers who supported logistics, data collection and translation, often under challenging conditions, and whose dedication ensured the success of this first phase of work.

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1 INTRODUCTION AND CONTEXT

Lebanon's diverse geography and ecosystems, stretching from the coastal plain to the interior mountains, are central to the country's economy and social identity. These landscapes are increasingly vulnerable to climate change, environmental degradation and economic stress. Rising temperatures, erratic rainfall and recurrent droughts are affecting agricultural production, water security and livelihoods, while political fragility and regional tensions add pressure on communities and institutions.

1.1 Purpose and scope

This report forms part of the EU-UNEP Climate Change, Environment and Security Partnership and focuses on the Akkar governorate in northern Lebanon. The project, "*Protecting Lebanon's forests to enhance local economies, build resilience to climate change and support regional peace and security*", was implemented by the Lebanon Reforestation Initiative (LRI) under contract to the United Nations Environment Programme (UNEP). Analytical and methodological support was provided by The Pearl (formerly the Walker Institute) at the University of Reading through a UNEP Small-Scale Funding Agreement (SSFA) under the wider transboundary adaptation and peacebuilding project, with regional insights contributed by the Royal Scientific Society of Jordan (RSS).

This first-phase technical report covers analysis and planning: mapping risks, identifying priority interventions and developing a locally grounded understanding of adaptation needs. It draws on complementary political, security and governance analyses completed in March to April 2025 to ensure that social stability and institutional feasibility were considered from the outset (see Appendix A8 Political and security assessment). The next phase will implement and test these measures, generating lessons for replication elsewhere and contributing to wider regional cooperation on adaptation under the transboundary programme funded through the SSFA provided to The Pearl.

Further background information is provided in **Appendix 1 Lebanon background** and **A3 Livelihood zone descriptions and maps**, which include the preliminary livelihood sub-zoning developed by LRI to inform participant selection for the consultations and workshop stages that followed.

1.2 Interdisciplinary and multi-sectoral design

The project was intentionally interdisciplinary, combining expertise in climate science, agriculture, forestry, livelihoods, social science and peace and security. This approach recognised that climate risk cannot be understood or managed within a single sector. Environmental degradation, economic vulnerability and local conflict are closely linked, and practical solutions depend on collaboration between sectors that do not often work together.

LRI's trusted role as a national implementing organisation was pivotal in bridging scientific, governmental and community actors. The Pearl's climate and social science researchers worked alongside LRI's field specialists and a peace and security expert, creating a genuinely multi-sectoral partnership that enabled a holistic view of how environmental stress, livelihoods and social stability interact.

1.3 Geographical and institutional context

The focus area, the Union of Jerd el Kayteh in Akkar, includes seven municipalities: **Bzal, Dinbou, Hrar, Michmich, Qabaait, Sfaynet el Qaitaa and Habchit**. Many of these towns are spread across two watersheds and rely on agriculture, forestry and natural resources for income and employment. They experience high levels of poverty and limited livelihood opportunities, with many households relying on remittances or seasonal work and a continuing outward migration of young people. Local governance capacity and municipal budgets are constrained, and competition over scarce resources has at times heightened social tensions, though long-standing mediation networks and inter-municipal cooperation have helped maintain stability. A rapid political and security context assessment confirmed that these informal mediation mechanisms provide a crucial platform for conflict prevention and should be integrated into future adaptation planning. Further detail on the political and security context is provided in Appendix A8 Political and security assessment.

The project was delivered through close collaboration among LRI, The Pearl and RSS, with oversight and guidance from UNEP West Asia. This combination of national leadership, regional insight and international analytical support created a platform for integrated, evidence-based adaptation planning that can inform similar efforts across the region. Analysis of livelihood-zone data (Appendix A3 Livelihood zone descriptions and maps) shows that upland forest degradation, mid-slope terrace collapse and coastal water stress follow this same spatial gradient, underscoring the need for watershed-level coordination.

1.4 Structure of the report

The report is organised from analysis through to action, lessons learned and conclusions.

- **Section 2** summarises observed and projected climate trends relevant to Lebanon and Akkar.
- **Section 3** presents the case-study analysis, describing the participatory process, community consultations, livelihood zoning, prioritisation and feasibility of adaptation measures.
- **Section 4** outlines the climate storylines produced from the modelling and bias-correction analysis.
- **Section 5** synthesises outcomes and adaptation interventions identified.
- **Section 6** sets out the lessons learned, including methodological innovations and the importance of interdisciplinary collaboration.
- **Section 7** provides conclusions and next steps, including alignment with national processes and regional learning.

Supporting data and workshop materials are provided in the Appendices: **A1** Lebanon background - national climatic and institutional context for the Akkar pilot**, A2** Climate data and analysis supplement, **A3** Livelihood-zone descriptions and datasets, **A4** Community consultations, **A5** Workshop outputs, **A6** NbS screening of interventions, **A7** Survey instruments, **A8** Political and security assessment, and **A9** Prioritisation criteria matrix.

2 CLIMATE ANALYSIS - HISTORICAL OBSERVATIONS AND TRENDS

This section summarises the climate and environmental evidence that underpins the Akkar case study. It brings together historical records, reanalysis datasets, satellite observations and community perspectives to describe how temperature, rainfall, ecosystems and hazards have changed across northern Lebanon, and how these patterns are projected to evolve over the coming decade.

The analysis was carried out in two stages. The first, undertaken during the April 2025 workshop, used ERA5 and ERA5-Land reanalysis, national data from MOE/UNDP/GEF (2019), and satellite platforms including Strata.EarthMap and Global Forest Watch to explore observed climatic and environmental change, covering rainfall anomalies, vegetation loss, wildfire occurrence and local hazard experience, through participatory mapping and discussion. The second stage, conducted between May and September 2025, produced statistically downscaled near-term projections using ERA5 and CMIP6 datasets accessed via the Copernicus Climate Data Store and the CEDA Archive. Together, these strands of work provide the empirical foundation for the participatory assessments described in Section 3 and the climate-livelihood storylines presented in Section 4.

2.1 Observed climate trends

Analysis of historical climate data for Lebanon, using ERA5 and ERA5-Land reanalysis together with national and satellite datasets, shows a consistent pattern of rising temperatures and increasing variability in rainfall over the past four decades (MOE/UNDP/GEF 2019; ERA5 2024; Pino Delgado 2025) (see **Figure 1**). Across the country, mean annual temperature has increased by about 1.75 °C since 1981, equivalent to roughly 0.4 °C per decade since 1981, with stronger warming inland and at higher elevations (Walker Institute 2025). The number of very hot days (> 35 °C) has increased markedly in low-lying areas, corresponding with community reports of prolonged heatwaves, livestock stress and reduced crop yields (LRI 2025; Pino Delgado 2025).

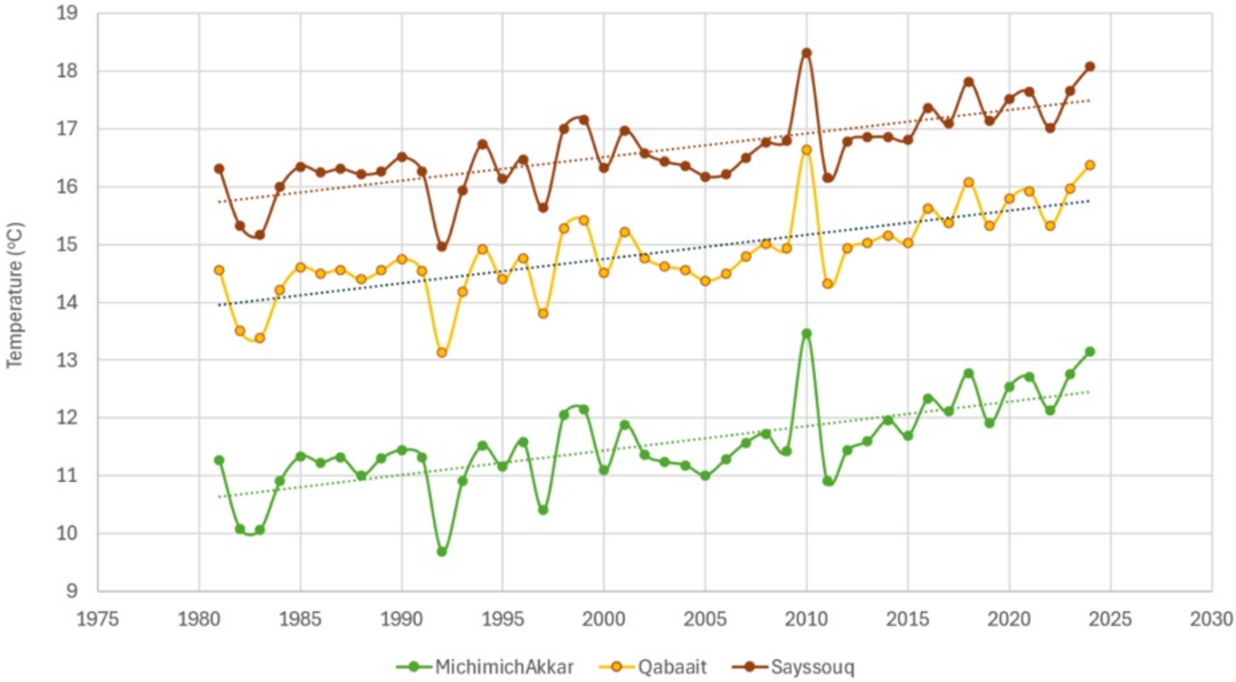

Figure 1: Average annual temperature trend for Lebanon, 1981-2024. Data from ERA5 reanalysis showing an approximate +1.75 °C increase. Source: Slides for Akkar Workshop, April 2025, Walker Institute (2025).

Rainfall records show no consistent long-term trend in annual totals, but clear evidence of greater year-to-year variability and shorter wet seasons. Since the early 1990s, the frequency of below-average rainfall years has increased, and the onset of the main rainy season has shifted later into autumn (MOE/UNDP/GEF 2019; Pino Delgado 2025) (see **Figure 2** and **Figure 3**).

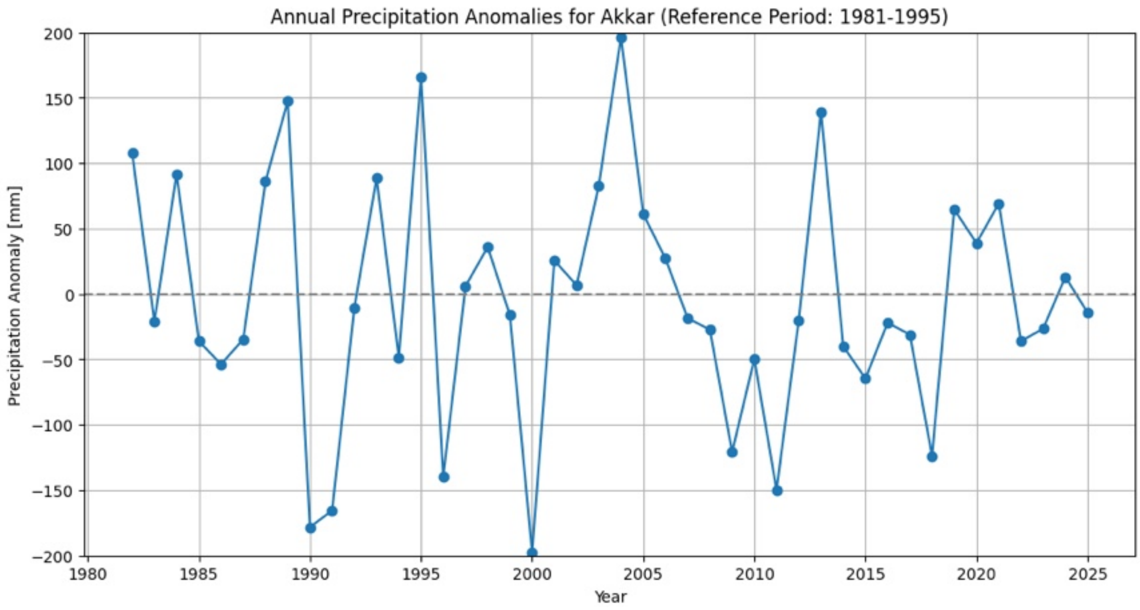

Figure 2: Annual precipitation anomalies for northern Lebanon (1981-2025). Source: Walker Institute (2025).

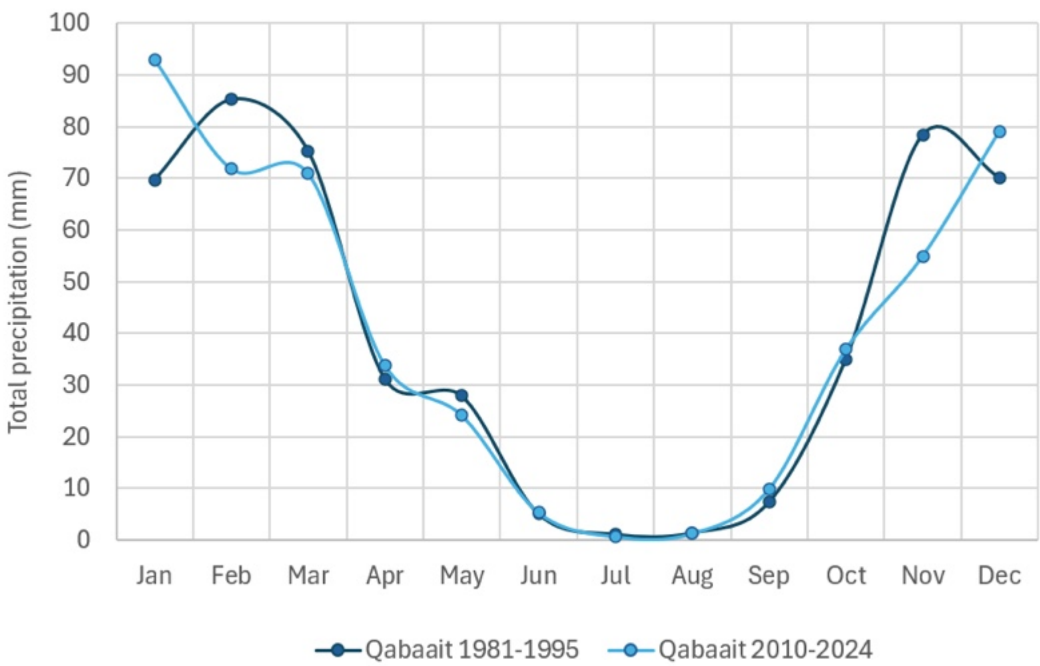

Figure 3: Shift in average total monthly rainfall between 1981-1995 and 2010-2024 showing later onset of autumn rains. Source: Slides for Akkar Workshop, April 2025, Walker Institute (2025).

The April 2025 workshop in Akkar visualised these changes using Strata.EarthMap, ERA5, and Global Forest Watch datasets to illustrate rainfall anomalies, vegetation-cover change and forest loss (Walker Institute 2025) (see

Figure 4). Participants observed that longer, hotter summers, delayed autumn rains and shorter wet periods have combined with more frequent flash floods and dry spells, directly affecting planting, water availability and soil retention (LRI 2025; Walker Institute 2025).

Figure 4: Tree cover loss from fires (brown, ha); tree cover loss due to other reasons e.g., deforestation (pink, ha) Global Forest Watch (2025).

Recent years have also seen recurrent droughts and more frequent flash-flood events, damaging terraces and rural roads (LRI 2025). Reduced fruit yields and increased pest outbreaks, reported by farmers illustrate how climatic stress is already impacting food systems (LRI 2025). Springs that once flowed year-round are now intermittent, reflecting broader pressures on groundwater resources (Walker Institute 2025). Satellite data show progressive vegetation loss and rising wildfire occurrence in the mountain forests of Akkar over the last two decades (Dr. Zarina Saidaliyeva, internal supporting documentation for April 2025 workshop; Global Forest Watch 2025) (see **Figure 4**).

Field evidence and testimonies gathered during the April workshop further documented soil degradation, crop stress and declining spring flows, which correspond closely with these climatic patterns. The agreement between instrumental records, reanalysis data, satellite observations and lived experience provides strong confidence that the region is already experiencing measurable climatic shifts that are impacting livelihoods and natural resources in Akkar (LRI 2025; Pino Delgado 2025; Walker Institute 2025). Supplementary figures and station data are provided in Appendix A2, including spatial maps of temperature and rainfall anomalies re-gridded on a 10 km grid. Further detail on data sources, station records and the bias-correction process is provided in **Appendix A2**.

2.2 Community-based observations

Community consultations held across the seven municipalities of the Union of Jerd el Kayteh provided qualitative evidence that complements the quantitative analysis of observed trends (LRI 2025; Walker Institute 2025). These consultations, undertaken before the formal climate-modelling phase, captured how households and farmers are already experiencing climatic change in daily life. Participants described a noticeable loss of seasonal predictability, a later onset of autumn rains, and an increase in crop and livestock losses caused by unseasonal storms and prolonged heat (LRI 2025) (see **Figure 3**).

Livestock herders observed shrinking pasture areas and greater dependence on purchased fodder, while households reliant on forestry reported rising fire risk and reduced forest regeneration (LRI 2025) (see **Figure 5**). Farmers commented that rains no longer come when expected, with some seasons bringing destructive downpours and others leaving fields dry for weeks (see **Figure 5**). They noted declining yields, particularly in fruit crops, and new pest outbreaks following unseasonal warmth and humidity (LRI 2025)

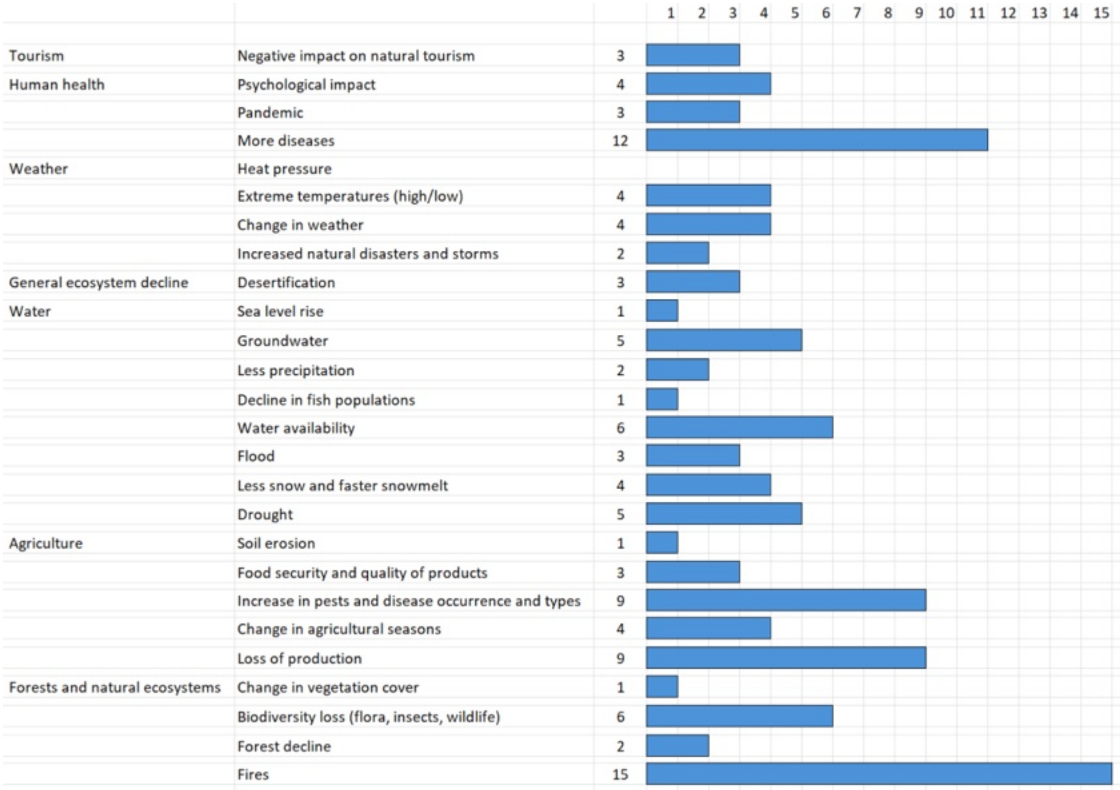

Figure 5: Community perceptions of climate-change impacts in Akkar (number of respondents citing each issue). Source: LRI (2025).

These findings were corroborated during the April 2025 workshop, where participants mapped local evidence of vegetation loss, drying of springs, changes in cropping areas and declining soil fertility (Walker Institute 2025) (see **Figure 6**) alongside ERA5 and Strata.EarthMap visuals.

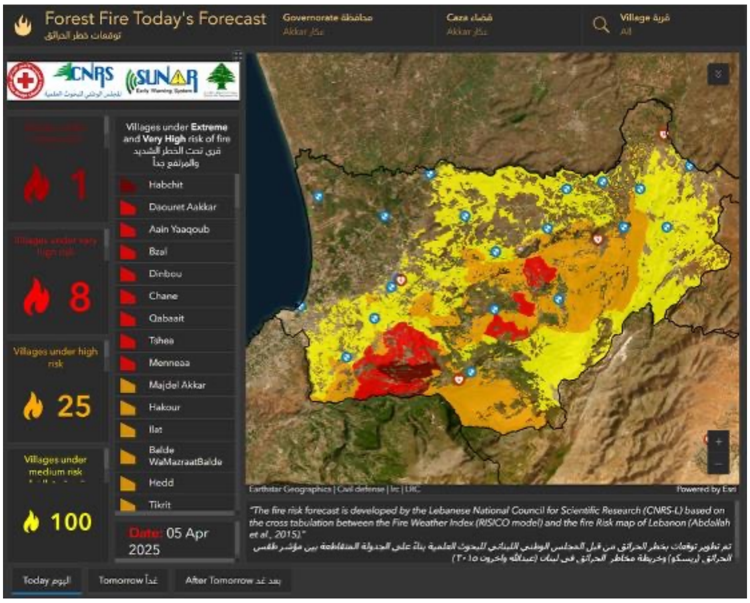

Figure 6: Photo documentation of drought impacts on agriculture and forest areas in Akkar, April 2025. Fires depend on type of vegetation and the shape of the land as well as several weather-related factors such as temperature, moisture and wind. With rising temperatures and changing rainfall patterns, fires may become more prevalent. The dry winter in 2024-25, has resulted in parched forests and scrub land, which are ideal fuel for fires. Arcgis screenshot shows the risk of fires in

Lebanon on 5th April 2025. Source:
https://www.arcgis.com/apps/dashboards/563d0603043640448882203a40d6d818.

Community groups emphasised three recurring themes:

1. **Water scarcity** - springs and small reservoirs dry earlier each year; irrigation costs are rising and local disputes over water use occasionally occur.
2. **Soil and vegetation loss** - steeper slopes show visible erosion and loss of tree cover, particularly after fire.
3. **Changing agricultural calendars** - planting and harvesting dates have shifted; fruit and olive yields now fluctuate sharply from year to year.

People also described how these physical impacts translated into social and economic strain. The shifting of planting and harvest seasons has made agricultural labour less predictable, creating uncertainty for wage workers and smallholders alike. Women farmers and landless labourers, who often depend on short seasonal contracts, reported greater difficulty planning income and balancing household responsibilities when the rains arrive late or end abruptly. These insights from diverse groups provided an early indication of where adaptation measures would need to address social vulnerability as well as biophysical risk.

Taken together, these communities' narratives correspond closely with the observed trends presented in Section 2.1. They show how people experience climate change through its direct effects on water, soil and vegetation, rather than abstract temperature or rainfall statistics. The rich local knowledge of micro-climates and coping practices, such as changes in crop choice, rainwater storage and terrace maintenance, have provided an essential basis for the adaptation planning described in Section 3. Additional participatory materials, including household perception charts and community-generated maps, are provided in **Appendix A4** (Community Consultations).

Examples of the participatory maps produced during these discussions are presented in **Appendix A4**.

2.3 Future projections and uncertainty

The forward-looking climate analysis for Akkar was developed in two distinct stages following the April 2025 workshop. The first stage extended the reanalysis datasets described in Section 2.1, using ERA5 and ERA5-Land products together with Strata.EarthMap visualisations to discuss possible future climate pressures in a participatory setting (Walker Institute 2025). These exercises helped participants relate observed trends to potential future risks but did not yet include the statistically downscaled projections.

The second stage, undertaken between May and September 2025, used near-term (2025-2035) statistically downscaled climate projections using ERA5 and CMIP6 datasets accessed via the Copernicus Climate Data Store and the CEDA Archive to generate climate storylines. Bias correction using Quantile Delta Mapping aligned model projections with observed data (Pino Delgado 2025). This analysis generated temperature, rainfall and humidity projections relevant for the next decade, timeframes directly informing local adaptation planning. Details of model selection, bias-correction and validation statistics are provided in **Appendix A2** for transparency and reproducibility.

Results indicate a continued warming trend of between +0.6 to +1.9 °C for the next decade in Akkar, with the greatest increases during summer. It is expected that the amount of very hot months (> P80 of historic summer temperatures) will be at least 3 to 4 months every year, increasing evapotranspiration and irrigation demand (Pino Delgado 2025).

Rainfall projections remain uncertain: annual totals vary between models, but all ensembles show greater intra-seasonal variability, characterised by short, intense rainfall events separated by longer dry spells (UNEP 2023; Pino Delgado 2025). Comparative rainfall-frequency charts derived from ERA5 and CMIP6 ensembles are included in **Appendix A2** to illustrate intra-seasonal variability.

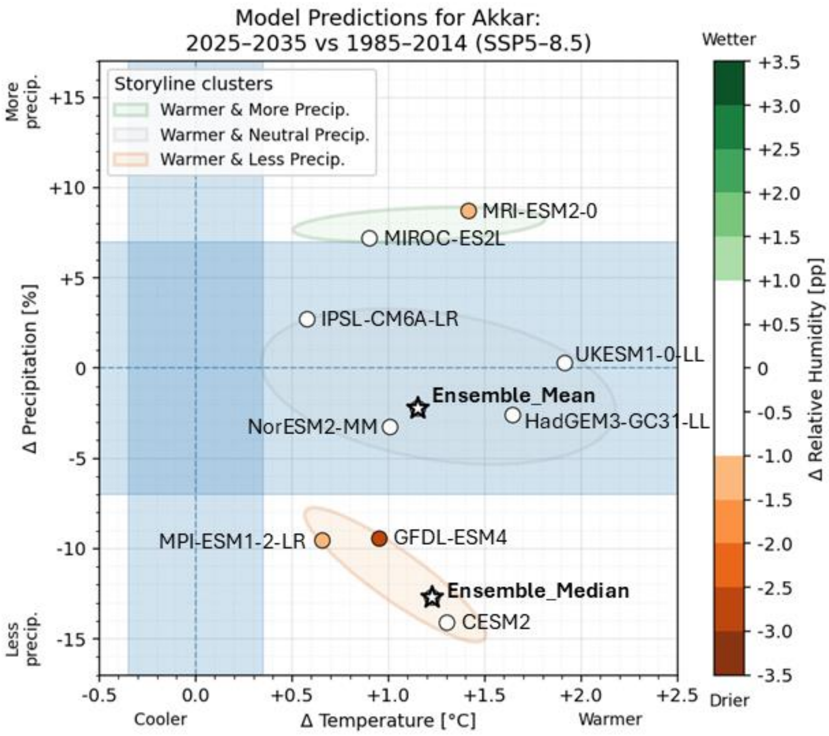

Figure 7: Three near-term climate storylines for Akkar (Hotter + Rainier; Hotter + Erratic Rainfall; Hotter + Drier). Source: Pino Delgado (2025).

From these results, three near-term climate storylines (CS) were derived (Pino Delgado 2025; see **Figure 7**):

CS1. Hotter + Rainier - heavier rainfall events during the cool season increase flood and disease risk but may enhance groundwater recharge in well-managed catchments;
CS2. Hotter + Irregular Rainfall - alternating wet and dry periods within the same season, leading to unpredictable planting calendars and greater risks from pests and diseases;
CS3. Hotter + Drier - prolonged dry seasons reduce water availability and accelerate loss of soil moisture and vegetation decline.

These projections were presented at the October 2025 UNEP coordination meeting, to inform scenario stress-testing of planned adaptation options. While temperature increases are consistent across models, rainfall patterns remain the main source of uncertainty. Overall, the results point to heightened climatic variability, amplifying water-management and livelihood challenges already observed in Akkar. This analysis provides the quantitative foundation for the participatory adaptation planning discussed in Section 3 and for the integrated climate-livelihood storylines detailed in Section 4.

Supplementary figures and model diagnostics, including ensemble spread and validation statistics, are provided in **Appendix A2** (Climate Data and Analysis). All shortlisted adaptation measures derived from this analysis were subsequently screened against UNEP (2024) Nature-based Solutions criteria to ensure coherence between evidence generation and intervention design (see Appendix A6).

2.4 Implications for livelihoods and adaptation planning

The combined evidence from the observed trends, community consultations and near-term projections highlights significant implications for livelihoods, ecosystems and local planning in Akkar. Rising temperatures and more frequent heat extremes will increase evapotranspiration, raising irrigation demand and accelerating soil drying (Pino Delgado 2025). Declining soil moisture and the shortening of the wet season are expected to further stress rain-fed agriculture and grazing systems, which are already under pressure from land degradation and fire risk (LRI 2025; Walker Institute 2025).

Under CS1, the Hotter + Rainier storyline, heavier rainfall events during the cool season (Pino Delgado 2025), increase flood risk for settlements, rural roads and terraces, but may also enhance groundwater recharge in well-managed catchments.

CS2, the Hotter + Irregular Rainfall storyline, suggests constant precipitation totals, but alternating wet and dry months that cause unpredictable planting calendars and greater risk from pests and diseases, particularly in fruit and vegetable crops.

In contrast, CS3, the Hotter + Drier storyline indicates prolonged dry seasons, intensifying water scarcity and further reducing forest and rangeland productivity.

For pastoralists, shifting rainfall patterns and vegetation loss are expected to reduce natural grazing areas, forcing greater reliance on purchased feed and seasonal migration to lower valleys (LRI 2025; Walker Institute 2025). Forest-based livelihoods face growing threats from wildfire and pest outbreaks, especially under CS3, the Hotter + Drier scenario. These combined pressures compound existing socio-economic vulnerabilities, particularly among smallholder farmers and wage-dependent households.

Despite these challenges, the near-term analytical horizon, covering the next decade, also offers an opportunity for locally driven adaptation planning. Measures that enhance soil and water retention, protect forest cover and promote efficient irrigation can deliver benefits under all three storylines. The participatory analyses presented in Section 3 build directly on this understanding, identifying community-led priorities that link climate resilience, natural resource management and livelihood security.

Spatial data supporting this analysis, including livelihood-zone delineation, are described in **Appendix A3** (Livelihood-Zone Descriptions and Maps). Additional contextual information on governance and security factors influencing implementation feasibility is summarised in **Appendix A8** (Political and Security Assessment).

3 PARTICIPATORY CONSULTATIONS AND ADAPTATION PRIORITIES

This section describes how the scientific evidence presented in Section 2 was translated into locally relevant adaptation priorities through a participatory process. The work as a whole was structured within the Implementation Centric Evolving Climate Change Adaptation Process (ICECCAP) described by Wells et al. (2023) and summarised in **Figure 9**.

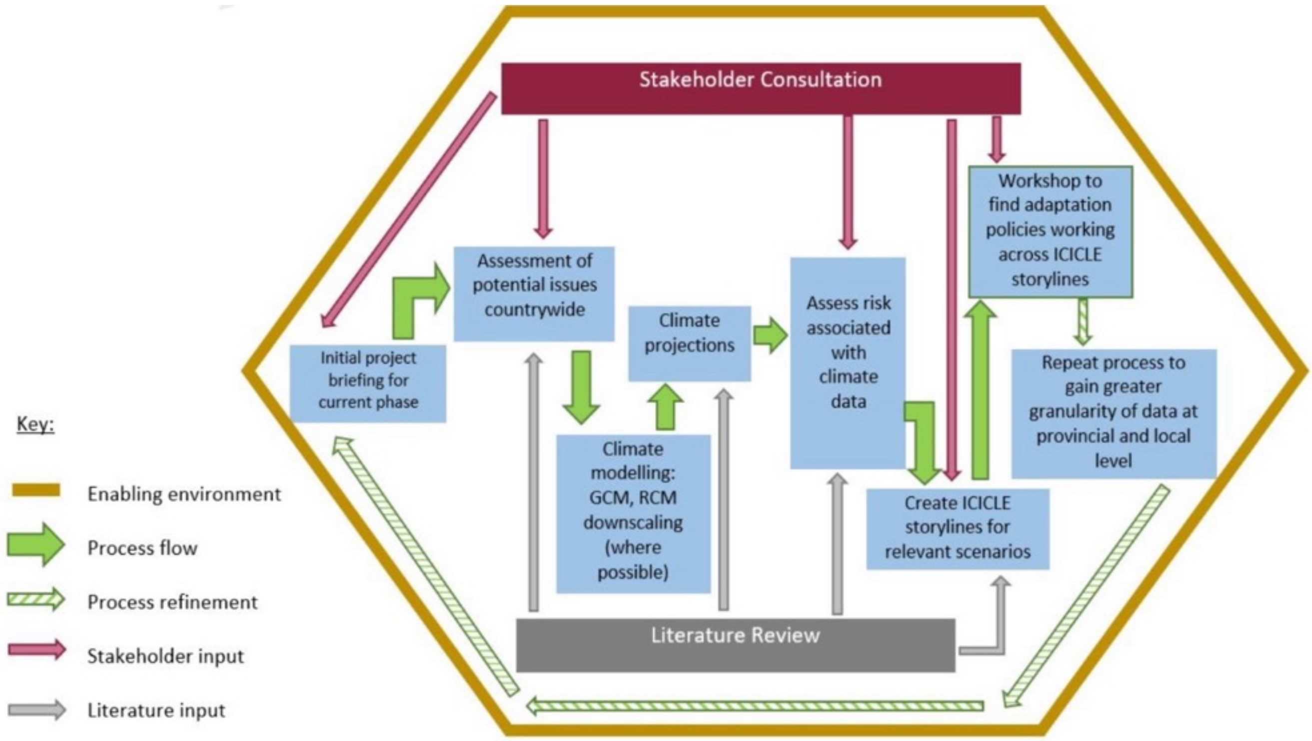

Figure 8: Schematic of the Implementation Centric Evolving Climate Change Adaptation Process (ICECCAP). Source: Wells et al. (2023) which the Akkar analytical and participatory process (Nov 2024-Oct 2025) is aligned with.

ICECCAP provided the overarching framework for the risk analysis and engagement, situating the climate assessment within an enabling environment that considers governance, resources and knowledge systems for implementation. It guided how scientific evidence, stakeholder insights and local experience were integrated to inform action, while the Inclusive Consultative Climate-Livelihood-Environment (ICICLE) storylines ran in parallel to connect climate information with livelihoods and decision processes.

Within this framing, the participatory approach combined structured consultations, community mapping and group exercises designed to connect observed and projected climate changes to specific livelihood and environmental impacts. It aimed to co-develop adaptation options that were both technically feasible and locally grounded.

Consultations took place between March and June 2025 across the seven municipalities of the Union of Jerd el Kayteh. They involved municipal representatives, farmers, pastoralists, women's groups and local NGOs, facilitated by the Lebanon Reforestation Initiative (LRI) with technical input from the Pearl team. The process included three stages: pre-workshop key-informant interviews to identify priority issues, a two-day participatory workshop held in Akkar in April 2025, and follow-up discussions to validate proposed adaptation measures.

The twelve-month sequence of analytical and participatory activities ran from November 2024 to October 2025, encompassing evidence generation, stakeholder engagement and synthesis, is illustrated schematically in **Figure 8**.

The following subsections outline the participatory methodology (3.1), summarise the consultation findings (3.2), present the livelihood-zone analysis used to interpret these results (3.3), and describe the adaptation priorities and community-selected measures (3.4).

3.1 Participatory process and stakeholder engagement

The participatory component of the Akkar project was designed to link scientific evidence with community-led insight through a structured and transparent process. The approach followed the principles of ICECCAP (**Figure 8**), embedding participation within an enabling environment for implementation rather than treating it as a single workshop event. The key stages of the participatory process are summarised schematically in **Figure 9**:

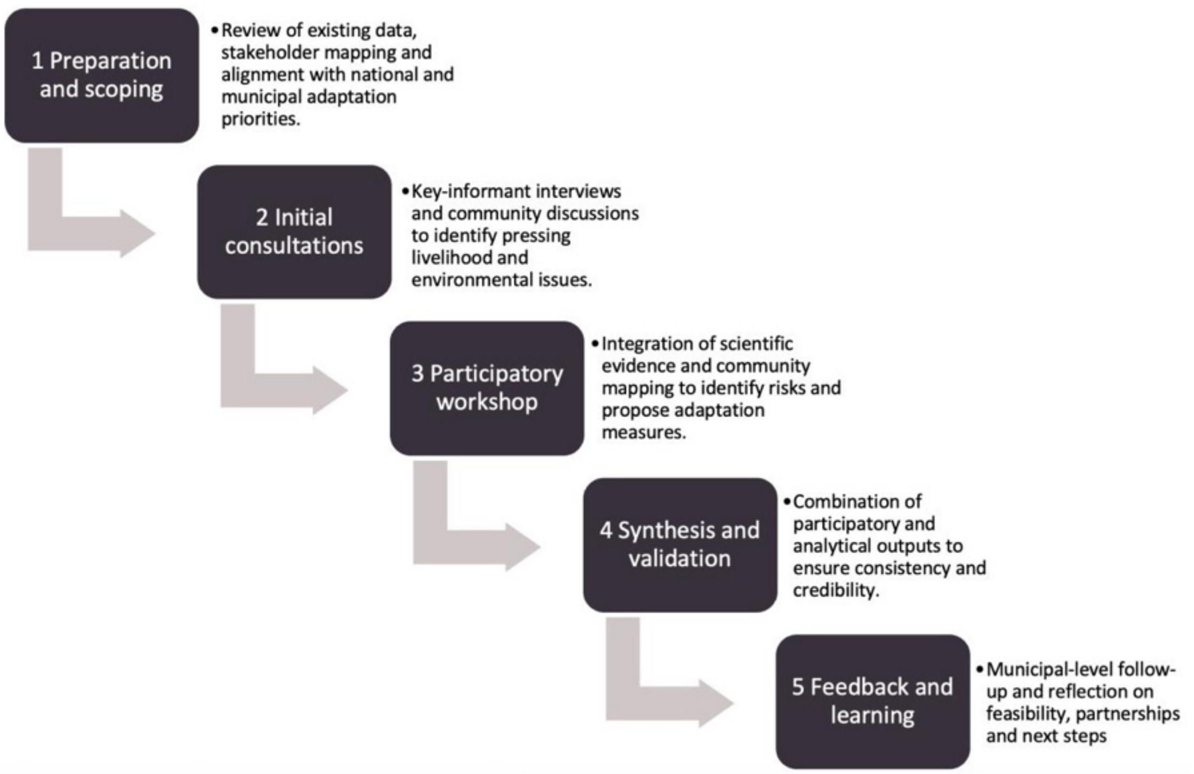

Figure 9: Key stages of the participatory process and stakeholder engagement in Akkar.

The methodology combined quantitative and qualitative techniques. Preparatory work included a review of secondary data, remote-sensing analysis and key-informant interviews with municipal officials, farmers' cooperatives and local NGOs. These steps identified local concerns about declining rainfall reliability, water scarcity and land degradation, and helped tailor the tools used in the field. Data were gathered using standardised Arabic-language questionnaires and focus-group guides, administered by trained local facilitators and digitised in KoboToolbox. Ethical protocols were followed, with verbal informed consent and no personal identifiers retained (see **Appendix A7 (Survey Instruments)**).

A summary of the consultation agenda, participant organisations and meeting locations is provided in **Appendix A4 (Community Consultations**). The semi-structured interview and discussion guides used during these preparatory activities are included in **Appendix A7**.

The main participatory workshop was held in Akkar in April 2025 and involved representatives from the seven municipalities of the Union of Jerd el Kayteh. Sessions were co-facilitated by the Lebanon Reforestation Initiative (LRI) and the Pearl team. Using participatory mapping, problem-tree analysis and group scoring, participants explored how observed and projected climate changes affect their livelihoods, natural resources and social well-being. The exercises built on ERA5 and EarthMap visualisations introduced earlier in the workshop, helping participants connect large-scale evidence with local experience. Illustrative workshop materials, including mapping outputs and group ranking sheets, are compiled in **Appendix A5 (Workshop Outputs).**

The facilitation approach aimed to widen participation, with targeted outreach to women producers, seasonal labourers and smaller landholders. Group work was mixed by municipality to encourage cross-community learning, while sensitive topics such as water access and grazing pressures were handled in plenary using agreed ground rules. This helped maintain trust across groups and ensured that less visible concerns, such as seasonal care burdens and access to inputs, were captured in these results.

Climate and environmental data from ERA5, EarthMap and Global Forest Watch were introduced in accessible visual formats to support discussion.

Outputs from the workshop included maps of perceived climate impacts, ranked lists of livelihood risks and a preliminary set of adaptation options. These results were later synthesised with quantitative analyses from The Pearl team to refine the evidence base for decision-making.

Follow-up activities from May to June 2025 involved feedback sessions in each municipality to validate the findings and ensure inclusion of under-represented groups, particularly women and smallholder farmers. Validation meetings were scheduled with women's groups and farmer cooperatives in each town to verify rankings and adjust where access or safety concerns had been under-reported. The approach emphasised mutual learning between scientists and communities, consistent with ICECCAP's focus on iterative knowledge exchange.

Detailed outputs from each stage, including photographs, facilitation notes and workshop materials, are compiled in **Appendix A5** (Workshop Outputs).

This structured process enabled rapid yet rigorous participatory engagement, ensuring that community perspectives were embedded within the broader analytical and policy framework described in Section 2, as summarised in **Figures 8 and 9.**

Full documentation of the consultation instruments, including the key-informant interview guide, focus-group discussion templates and the community-consultation questionnaire, is provided in Appendix A7. These tools ensured consistency across municipalities and enabled systematic comparison of local observations, livelihood impacts and adaptation priorities. The anonymised datasets generated through these instruments underpin the qualitative analysis presented in Sections 2.2 and 3.2, and form part of the monitoring and learning framework for Phase II.

3.2 Stakeholder consultations and community insights

The consultations drew on the structured instruments described in Appendix A7, which combined key-informant interviews, focus-group discussions and a standardised community-consultation questionnaire to ensure comparability across municipalities.

Consultations across the seven municipalities of the Union of Jerd el Kayteh provided the foundation for identifying locally relevant adaptation priorities. Participants represented municipal councils, farmers' and women's associations, youth groups and local NGOs. The process was facilitated by the Lebanon Reforestation Initiative (LRI) with technical support from the Pearl team. It aimed to capture the full range of local perspectives on climate risks, livelihood challenges and feasible response options.

During the pre-consultation phase (March 2025), key-informant interviews were conducted in each municipality to gather initial perceptions of environmental and livelihood stressors. Common concerns included declining rainfall reliability, reduced spring discharge, soil erosion, loss of productive land and an increase in forest fires. A complete list of stakeholders consulted and the issues raised in each municipality is presented in **Appendix A4 (Community Consultations)**. These insights informed the design of the April 2025 participatory workshop.

At the April 2025 workshop, participants examined observed and projected climate trends presented by the Pearl team and related these to changes they had experienced. Discussions confirmed that longer dry periods, more intense rainfall events and rising temperatures are already affecting farming, forestry and water supply. Communities linked these changes to declining yields, increased pest and disease incidence, and growing tension over water use. The exercise produced qualitative maps of local hazards and vulnerability "hotspots," identifying the most affected households and sectors. Women's groups emphasised the effects on domestic water management and food processing, while young participants highlighted the implications for employment and migration. These perspectives underscored how climate stress intersects with wider livelihood insecurity and demographic pressures in Akkar.

Range of potential adaptation measures identified and ranked by partners

SECTOR	ADAPTATION MEASURE
Agriculture	Alternative agricultural approaches; advanced farming equipment; capacity-building on best practices; awareness-raising on sustainable agriculture.
Ecotourism	Promotion of ecotourism practices.
Energy	Solar power generation; small-scale hydropower.
Forestry	Reforestation; establishment of nature reserves; improved forest management; integration of ecotourism; creation of public gardens.
Public services	Road construction; agricultural police station; fire station; provision of firefighting vehicles.
Solid waste management	Development of waste sorting facilities.
Water and irrigation	Construction of water ponds, canals, dams, purification plants; rainwater collection outlets; fire water outlets; retention walls; wells.

Figure 10: Examples of participatory outputs from stakeholder consultations, showing ranked adaptation options (see also **Table 1)** produced during the April 2025 workshop. Source: LRI (2025) and Pearl team records; examples with details provided in **Appendix A5.**

Following the workshop, validation meetings were held in May and June 2025 in each municipality. These sessions refined the results and checked that proposed adaptation measures reflected diverse local priorities. Particular attention was paid to conflict-sensitivity, the needs of women and the poorest households and the importance of maintaining cooperation between neighbouring communities that share natural resources. Supplementary workshop materials, including photographs and facilitation templates, are available in Appendix A5 (Workshop Outputs).

Three cross-cutting insights emerged:

1. **Water stress** is the defining local concern. All communities reported earlier drying of springs, declining groundwater levels and the rising cost of irrigation.
2. **Livelihood insecurity and environmental degradation** are tightly linked. Land abandonment, over-grazing and deforestation were repeatedly identified as both causes and consequences of climate stress.
3. **Collective action remains a local strength**. Existing municipal committees and cooperatives provide entry points for implementing adaptation measures if technical and financial support can be secured.

These findings confirmed that communities already recognise the symptoms of climate change and are eager to act but require coordinated technical and institutional support to translate ideas into implementation. The following section (3.3) describes how the livelihood-zone analysis was used to interpret these insights and inform the prioritisation of adaptation measures.

3.3. Livelihood-zone analysis

To interpret the consultation results in spatial context, a livelihood-zone analysis was carried out for the Union of Jerd el Kayteh and its surroundings (**Figure 11**). This analysis built on previous national zoning work and combined satellite-based land-use classification with participatory validation undertaken during the April 2025 workshop. The aim was to identify areas with shared livelihood characteristics and exposure to similar climate and environmental stresses.

Building on this initial work, four main zones were distinguished:

1. **Agricultural lowlands**, where mixed cropping and horticulture dominate and irrigation demand is high.
2. **Forest and rangeland uplands**, characterised by forestry, grazing and seasonal labour migration.
3. **Mixed transitional areas**, combining small-scale farming and orchard production with remittance-supported livelihoods.
4. **Urban and peri-urban settlements**, centred on trade, services and off-farm income.

These zones, shown in **Figure 11**, correspond to the maps showing specific livelihood activities, presented in **Appendix A3**.

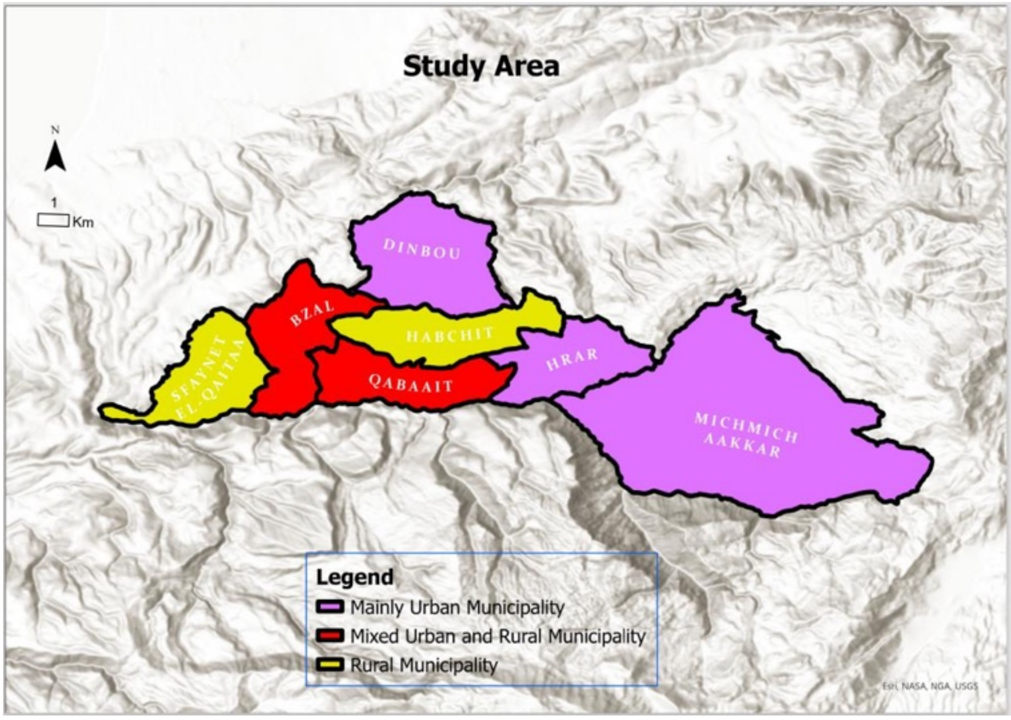

Figure 11: GIS map including Akkar Governorate with administrative boundaries of target municipalities shown in black. Preliminary broad livelihoods classification has been superimposed as follows: mainly rural municipalities (Habchit, Sfaynet Qaitaa) are highlighted in yellow. Mixed urban/rural municipalities (Bzal, Qabaait) are highlighted in red and the mainly urban municipalities (Michmich, Hrar, Dinbou) are shown in purple. Source: Pearl team and LRI Akkar Workshop, 2025. See also **Appendix 3**.

Overlaying the zones with observed and projected climate data highlighted distinct patterns of vulnerability. The agricultural lowlands face increasing irrigation stress and soil degradation; the upland forest and rangeland areas are more exposed to drought, erosion and fire risk; mixed zones show complex dependencies on both rainfall and market access; and the urban/peri-urban areas are vulnerable to water-supply interruptions and livelihood displacement.

The zonal framework provided a practical bridge between scientific analysis and community knowledge, enabling local actors to discuss adaptation priorities at a spatial scale they recognise. Examples of the participatory maps that informed this analysis are provided in Appendix A5 (Workshop Outputs), while detailed zone descriptions and GIS data are included in **Appendix A3 (Livelihood-Zone Descriptions and Maps)**.

During the mapping exercise, facilitators also recorded access issues raised by women and by smaller producers, including distance to water points, slope stability on footpaths and the cost of transporting inputs. These practical insights were incorporated into the livelihood-zone descriptions and used to check that the boundaries captured how people actually move, farm and use resources on a daily basis.

This zonal framework later served as the spatial reference for evaluating adaptation options during community prioritisation (see Section 3.4).

3.4 Community adaptation priorities and proposed measures

Building on the livelihood-zone analysis, partners (LRI with support from The Pearl and UNEP) identified and ranked adaptation measures addressing the main risks highlighted during the consultations. The process linked local priorities with nature-based solutions (NbS) principles and with the practical constraints of implementation in Akkar's social and environmental context.

Inclusion shaped both the choice and the design of measures. For example, harvesting ponds and terrace repair were prioritised where women and smaller producers could access them without additional cost or risk, and training topics were selected to match seasonal workloads. These design choices were discussed openly to maintain transparency and ensure solutions remained feasible for all groups.

Across the seven municipalities, communities focused on three core sectors: water, agriculture, and forests. The most frequently cited concerns were declining water availability, soil erosion, loss of vegetation cover, and the growing incidence of wildfires. Measures were ranked using a transparent, multi-criteria matrix, with scores validated collectively in plenary to ensure transparency and trust (see **Appendix A9**).

Water management: Communities placed highest priority on interventions that conserve, harvest and distribute water more efficiently. These included:

- Rehabilitation of traditional cisterns and small reservoirs to capture winter rainfall.
- Construction of new water-harvesting ponds and small retention basins in upland areas.
- Promotion of drip irrigation and soil-moisture conservation techniques.
- Protection and re-vegetation of catchment areas to enhance infiltration and reduce erosion.

Agricultural resilience: In agricultural zones, participants proposed actions to restore soil fertility and reduce vulnerability to drought including

- Terrace repair and maintenance using locally available materials.
- Introduction of drought-tolerant crop varieties and improved crop rotation.
- Establishment of community seed banks and on-farm demonstrations of resilient practices.

Forest and rangeland management: Upland communities identified the loss of forest cover and over-grazing as major risks. Proposed measures included:

- Firebreak construction and maintenance to reduce wildfire spread.
- Assisted natural regeneration and selective planting of native species.
- Development of community grazing plans and rotational pasture systems.
- Awareness campaigns on fire prevention and sustainable wood use.

Cross-cutting measures: Participants also emphasised actions to strengthen local institutions and promote joint management between municipalities, such as:

- Establishing local adaptation committees to coordinate interventions across administrative boundaries.
- Training programmes for youth and women's groups in water management, nursery production and forest restoration.

Participatory monitoring of implemented measures will be used to track performance and share lessons.

Table 1: Summary of community-prioritised adaptation measures by sector and feasibility rating. Source: LRI (2025), Pearl team synthesis based on **Appendix A6 and A9**.

Town	Adaptation Measure	Site Score Based on Prioritization Criteria
Hrar	Implementing adaptation measures on agriculture lands including adopting alternative agriculture based on local species that enhances soil quality, conducting awarness sessions for farmers, and adopting drip irrigation for water conservation	0.83
Qabaait	Implementing adaptation measures to enhance agriculture yield including conducting awarness campaigns, providing advanced agriculture equipment to reduce manpower cost, implement alternative agriculture solutions to respond to climate change	0.795
Hrar	Implementing adaptation measures on agriculture lands including adopting alternative agriculture based on local species that enhances soil quality, conducting awarness sessions for farmers, and adopting drip irrigation for water conservation	0.78
Michmich	Replacing existing crops with rainfed or forest fruit trees (Pinus pinea, Sumac, walnut, etc.)	0.77
Michmich	Replacing existing crops with rainfed or forest fruit trees (Pinus pinea, Sumac, walnut, etc.)	0.77
Michmich	Replacing existing crops with rainfed or forest fruit trees (Pinus pinea, Sumac, walnut, etc.)	0.77
Hrar	Implementing adaptation measures on agriculture lands including adopting alternative agriculture based on local species that enhances soil quality, conducting awarness sessions for farmers, and adopting drip irrigation for water conservation	0.76
Hrar	Implementing adaptation measures on agriculture lands including adopting alternative agriculture based on local species that enhances soil quality, conducting awarness sessions for farmers, and adopting drip irrigation for water conservation	0.76
Dinbou	Adopting agriculture in greenhouses (including receiving capacity building sessions and implementing new irrigation techniques like drip irrigation)	0.745
Hrar	Installing fire water outlets, building artificial lakes to support irrigation and firefighting efforts, and installing rainwater collection outlets (for fire response)	0.73
Hrar	Installing fire water outlets, building artificial lakes to support irrigation and firefighting efforts, and installing rainwater collection outlets (reservoirs to collect water from irrigation canals and help in irrigation of agricultural lands)	0.68
Hrar	Installing fire water outlets, building artificial lakes to support irrigation and firefighting efforts, and installing rainwater collection outlets (reservoir for agricultural irrigation)	0.68
Hrar	Reforesting area and protecting it from grazing	0.5
Qabaait	Enhancing ecotourism around river banks	0.495
Hrar	Establishing a nature reserve and enhancing ecotourism in forested areas	0.495
Hrar	Reforesting area and protecting it from grazing	0.45
Hrar	Reforesting area and protecting it from grazing	0.45
Hrar	Reforesting area and protecting it from grazing	0.45
Sfaynet El Qaitaa	Reforesting	0.4425
Sfaynet El Qaitaa	Reforesting	0.4425

Each measure was screened for compliance with NbS criteria (see Appendix A6) and cross-checked against the prioritisation matrix (Appendix A9) to ensure that technical feasibility, gender inclusiveness and conflict-sensitivity were considered together. The summary is shown in **Table 1**.

The resulting portfolio provides a realistic starting point for the next phase of implementation. Detailed descriptions, feasibility notes and supporting tables are presented in Appendices A4 to A6 and A9.

In Phase II, weightings will be refined through cost-benefit analysis to guide site selection and sequencing (see Section 6).

4 CLIMATE-LIVELIHOOD-ENVIRONMENT STORYLINES

Climate information becomes most useful when it helps people anticipate the conditions they are likely to face and test whether planned actions will still hold under different futures. Building on the participatory analysis described in Section 3, this section translates the scientific evidence from Section 2, and the participatory insights from Section 3 into decision-centred, people-focused narratives of change.

Using the ICICLE (Inclusive Consultative Integrated Climate, Livelihoods and Environment) framework for integrating climate and livelihood evidence, and nested within the ICECCAP enabling environment, these storylines link physical climate projections with social and economic realities in Akkar. They provide a bridge between data and decision-making, enabling adaptation options to be stress-tested against plausible near-term climate futures.

4.1 Purpose and approach

The storyline approach was used to translate complex climate information into decision-relevant narratives that reflect how changes in temperature, rainfall and seasonality affect people and livelihoods. Within the ICICLE framework, physical climate evidence was combined with socio-economic to generate coherent, locally grounded storylines. These ran in parallel with the ICECCAP enabling environment described in Section 3, ensuring that the analysis remained implementation-centred rather than purely diagnostic.

The storyline development drew on statistically downscaled climate data (Section 2.3), livelihood-zone mapping (Section 3.3) and community priorities (Section 3.4). Each storyline describes a plausible near-term (2025-2035) climate trajectory and its potential consequences for livelihoods, resource management and adaptation needs in Akkar.

Supplementary datasets and a description of the storyline-building workflow are provided in Appendix A2 (Climate Data and Analysis) and Appendix A3 (Livelihood-Zone Descriptions and Maps). These show how downscaled climate variables were linked to livelihood zones and community priorities through the ICICLE process.

4.2 The three Akkar Climate Storylines

As summarised earlier in the report, three plausible near-term storylines (CS1-CS3) were developed to capture the range of projected climate-livelihoods futures for Akkar from cluster analysis of downscaled CMIP6 projections and validation against ERA5 trends (Pino Delgado 2025; see **Figure 7**).

CS1: Hotter + Rainier - heavier rainfall events during the cool season increase flood and disease risk but may enhance groundwater recharge in well-managed catchments;

CS2: Hotter + Irregular Rainfall - alternating wet and dry periods within the same season, leading to unpredictable planting calendars and greater risks from pests and diseases;

CS3: Hotter + Drier - prolonged dry seasons reduce water availability and accelerate loss of soil moisture and vegetation decline.

The combined climate-livelihood-environment storylines generated (ICICLES) synthesised the projected changes with the livelihood impacts across the four zones described in Section 3.3.

4.3 Linking climate-livelihood storylines (ICICLES) to adaptation planning

Each storyline was used to stress-test the adaptation options identified through the participatory process, ensuring consistency with community-identified vulnerabilities (Section 3.4). For example:

- For CS1, the **Hotter and Rainier storyline**, longer and hotter summers, with more variable rainy season onsets, and yearly humidity spikes create a more challenging environment for agriculture in Akkar. While overall rainfall is slightly higher, it comes in irregular bursts, with both flood and dry risks present within the same season. This storyline suggests that farmers will face a familiar but more volatile climate, requiring greater flexibility in planting, water management, and post-harvest practices.

- For CS2, the **Hotter with Disrupted Rainfall storyline**, it is expected a climate that feels familiar in its broad outline (hot dry summers, wet cool winters) but that gets increasingly erratic in its details. Summers are reliably longer and hotter, winters retain occasional but unpredictable cold anomalies, and the wet season is punctuated by both floods and dry spells. Farmers face the challenge of planning for extremes on both ends of the spectrum, within a climate that looks familiar in its seasonality but is increasingly volatile in its behaviour.
- For CS3, the **Hotter and Drier storyline** describes a climate of longer, hotter summers, shorter and less reliable rainy seasons, and greater volatility within the cool months. Farmers face the prospect of a consistently harsher summer, a delayed onset of life-giving rains, and alternating wet and dry extremes within the same season. Although the average outlook is drier, the main challenge lies not only in less rainfall but in its erratic timing and intensity, which may stretch both agricultural practices and water management systems to their limits.

These narratives provide a foundation for exploring adaptation strategies under different but plausible future conditions.

Integrating the storylines with the prioritisation matrix will allow communities and technical teams to examine how each measure performs under different plausible futures. This approach provides a transparent way to evaluate trade-offs and synergies across a range of adaptation options, and to identify "no-regret" actions that remain effective across scenarios. For example, soil stabilisation terrace repair scored highly across all scenarios, demonstrating how the process identified robust, low-regret measures. Detailed tables linking each community-selected measure to its performance under the three storylines can be developed in Phase II, building from the matrices co-validated with LRI facilitators to ensure local feasibility and gender inclusion (see **Appendix A9).**

4.4. Lessons for Climate-Livelihood storylines and ICECCAP integration

The storyline process in Akkar demonstrates the value of combining the ICICLE and ICECCAP frameworks in time-constrained and data-limited contexts. Using storylines enabled rapid co-interpretation of scientific outputs and community evidence, while ICECCAP ensured that governance, financing and capacity considerations were addressed concurrently.

The integrated approach provided three clear benefits:

1. Coherence - scientific and local knowledge were integrated from the outset, avoiding the common sequencing gap between analysis and engagement.
2. Transparency - decision options could be traced directly to evidence and assumptions.
3. Actionability - results fed immediately into the design of the next-phase implementation plan (Section 6).

Supporting figures, datasets and extended storyline narratives are provided in **Appendix A2 (Climate Data and Analysis)** and **Appendix A3 (Livelihood-Zone Descriptions and Maps).**

4.5 Implications for scaling and replication

The storyline approach developed for Akkar demonstrates how integrated, evidence-based planning can be applied rapidly and collaboratively in fragile settings. The combination of ICICLE and ICECCAP allowed technical analysis and community engagement to evolve together, ensuring that results were immediately useful for decision-making.

The methodology provides a transferable model for other regions where climate pressures, ecological fragility and social vulnerability intersect. By adapting the same approach, linking downscaled climate data, livelihood mapping and participatory prioritisation, neighbouring governorates and transboundary basins can generate comparable climate-livelihood storylines to support coordinated adaptation and peacebuilding.

This foundation will inform regional learning under UNEP's Climate, Environment and Security Partnership and contribute to the design of Phase II activities described in **Section 6**.

Appendix A8 (Political and Security Assessment) summarises governance and security factors that should be reviewed when replicating the storyline approach in other regions. **Appendix A9** provides the template matrix for adaptation-option evaluation to support this replication.

This methodology now provides a tested foundation for replication across Lebanon and neighbouring regions facing similar climate and governance challenges.

5 LESSONS LEARNED AND METHODOLOGICAL INNOVATIONS

5.1 Overview

The Akkar pilot offers practical insights into how integrated climate-risk assessment and participatory planning can be undertaken effectively in data-limited and institutionally complex environments. The process showed that rigorous, evidence-based adaptation planning is possible within short project windows when scientific and local knowledge are brought together from the outset.

These lessons span three main areas: methodological innovation and participatory practice, operational delivery and institutional coordination, and interdisciplinary collaboration with implications for scale; each are discussed below. Together, these themes capture how analytical tools, partnership models and cross-disciplinary working methods contributed to an approach that is both technically robust and locally grounded.

5.2 Methodological innovation and participatory practice

The methodological lessons below summarise how the analytical and participatory components were integrated and which design choices most influenced the quality, inclusiveness and transferability of results.

(i) Integration of ICECCAP and ICICLE

The combined use of ICECCAP and ICICLE frameworks proved central to the project's effectiveness. Embedding the climate-risk assessment within ICECCAP's enabling environment ensured that institutional, resource and capacity factors were considered from the start. Running ICICLE (Inclusive Consultative Integrated Climate, Livelihoods and Environment) storylines in parallel connected physical science outputs to people's lived experience, producing narratives that could directly inform adaptation decisions. This integration allowed evidence to move rapidly from analysis to action and provides a transferable model for other regions (see Wells et al. 2023).

(ii) Rapid ICICLE process

Conducting analytical and participatory work in parallel, rather than sequentially, shortened delivery time while maintaining quality. The use of existing datasets (ERA5, CMIP6, EarthMap) combined with participatory validation produced robust near-term climate-livelihood storylines within a few months.

(iii) Hybrid livelihood-zoning approach

Combining remote-sensing analysis with participatory validation generated trusted, conflict-sensitive maps. This approach proved essential for linking climate evidence to spatial decision-making and for identifying where interventions would have the most equitable impact. The mapping exercises also highlighted that participation quality matters as much as technical precision. Ensuring that women, youth and smaller producers were represented in validation sessions increased the legitimacy of the resulting maps and built confidence among participants in how evidence was applied. The approach also highlighted the value of early context familiarisation, allowing facilitators to link technical mapping outputs with social and institutional realities. Such inclusive facilitation practices are now being adapted for use in other Pearl projects.

(iv) Participatory prioritisation

The structured ranking of adaptation measures (**Appendix A9 - Prioritisation Criteria Matrix**) allowed transparent evaluation of options and provided a shared platform for negotiation between communities and technical experts. Integrating gender and conflict-sensitivity criteria improved the legitimacy and practicality of results. Interdisciplinary collaboration further strengthened the process. Integrating gender and conflict-sensitivity criteria improved the legitimacy and practicality of results while interdisciplinary collaboration further strengthened the process. This broader lens helped ensure that proposed measures were both technically sound and socially feasible.

(v) Practical tools for replication

Several innovations developed through this work can inform other UNEP adaptation initiatives, including:

- **Decision-centred storylines** that link quantitative projections with qualitative community evidence (see **Appendix A2 and Appendix A3**).

- **Simplified NbS screening tools** (**Appendix A6**) adaptable for rapid field validation.
- **Multi-criteria prioritisation matrices** (**Appendix A9**) that capture technical, social and environmental dimensions simultaneously.
- **Template workflows** for aligning ICECCAP and ICICLE within short-duration projects (**Appendix A5**, project records).

Each of these tools is provided as a working example in the associated appendices to support replication in Phase II and other UNEP adaptation initiatives.

5.3 Operational delivery and institutional coordination

The following lessons concern project management, partnership and coordination arrangements that enabled effective delivery within short timeframes and a complex institutional environment.

(i) Interdisciplinary collaboration

The project demonstrated the value of bringing together specialists from climate science, livelihoods analysis, environmental management, and peace and security. Having social scientists and a peace and security expert alongside natural science researchers improved contextual understanding and strengthened conflict-sensitive design.

(ii) Partnership with LRI

Working with the Lebanon Reforestation Initiative as a trusted national partner was crucial for building local ownership and maintaining continuity during periods of administrative delay. LRI's presence and relationships enabled effective coordination and rapid mobilisation of participants.

(iii) Flexibility and iteration

Time constraints required adaptive management, with analytical and engagement activities proceeding concurrently. Regular cross-team meetings, supported by UNEP's coordination, ensured that scientific outputs and field feedback evolved together rather than in isolation. Combining social science and peace and security expertise with climate and environmental analysis improved early risk sensing and helped avoid adaptation choices that might unintentionally increase competition over water or pasture. Embedding this mix of perspectives early in the project cycled proved vital for context-sensitive design and strengthened coordination between technical and community teams. Clear timely communication with the UNEP and national partners also facilitated adaptation to evolving institutional and political contexts. Regular sharing of draft outputs built transparency and ensured that emerging evidence could inform wider programme planning under the EU-UNEP Climate Change, Environment and Security Partnership.

These coordination and communication practices provide a practical model for managing interdisciplinary teams under time and resources constraints.

Further documentation of coordination arrangements, meeting records and lessons on partnership management is provided in **Appendix A8 (Political and Security Assessment)**, which summarises institutional relationships and decision pathways relevant to future scaling.

5.4 Interdisciplinary collaboration and implications for scale

The Akkar experience shows that progress on adaptation in fragile settings depends less on generating new data but on the way, evidence is connected and applied across disciplines. Integrating climate science and community knowledge within a single framework proved decisive. The combination of ICECCAP and ICICLE enabled scientific analysis and participatory learning to evolve together, giving the process both rigour and relevance. Early contextual familiarisation, continuous dialogue between natural and social scientists, and the inclusion of peace and security perspectives ensured that adaptation options were conflict-sensitive and locally grounded.

Throughout the project, reflection and feedback were embedded to foster transparency, trust and ownership among participants, while the hybrid livelihood-zoning and rapid storyline approaches made technical outputs accessible and actionable. Taken together, these methodological advances demonstrate that even under tight timelines and institutional constraints, it is possible to design evidence-based adaptation plans that strengthen both resilience and cooperation.

The innovations developed in Akkar now provide a transferable foundation for implementation in other regions facing similar climate and governance challenges. They also illustrate how multi-disciplinary teams, working in partnership with local institutions, can translate complex climate data into practical pathways for resilience and peace.

An overview of supporting material for this section, including workshop reflections, NbS screening tables, political and security analysis, and prioritisation matrices, is provided in **Appendices A5, A6, A8 and A9.**

6 NEXT STEPS AND IMPLEMENTATION PLAN

Building on the interdisciplinary lessons outlined in Section 5 (Lessons learned and methodological innovations), Phase II will translate these findings into implementation. It builds directly on the evidence, methods and partnerships developed in Phase I, translating the integrated climate-livelihood storylines and community priorities into practice on the ground. This section summarises the focus and governance of the implementation phase and outlines how The Pearl will continue to provide targeted technical support, monitoring and synthesis between October 2025 and September 2026.

Detailed implementation steps are presented in **Annex A (Implementation Plan)** and supported by **Appendices A4-A8**, which provide the consultation results, NbS screening, and political-institutional context used to define Phase II actions.

6.1 Purpose and scope

Phase II will put into practice the findings of this analysis through community-led adaptation actions coordinated by the Lebanon Reforestation Initiative (LRI), with technical backstopping from The Pearl and oversight by UNEP West Asia. Phase II aims to consolidate the analytical and participatory achievements of Phase I through four main objectives:

1. Finalise and pilot a local agricultural adaptation strategy for the Union of Jerd el Kayteh;
2. Strengthen capacity among farmers and municipal institutions for climate-resilient practices;
3. Implement one or more water-related, nature-based interventions; and
4. Continue learning and stress-testing of adaptation options using the ICICLE-ICECCAP framework.

These objectives will be supported by The Pearl's continuing technical inputs and coordination with LRI under UNEP's oversight. Detailed implementation steps are outlined in **Annex A (Implementation Plan)** and in **Appendices A4 to A8**, which document the evidence base for these actions.

6.2 The Pearl's technical-support role

During Phase II, subject to funding, The Pearl would aim to provide targeted technical inputs and cross-learning support. This work would include scenario stress-testing of adaptation measures (see Annex Output 1.7) using the ICICLE and ICECCAP frameworks with the My Climate Risk methodology; advice on monitoring, evaluation and learning (MEL) indicators linked to climate suitability and livelihood outcomes. This support would ensure that analytical consistency and learning are maintained between the local and regional components of the UNEP's transboundary programme. The Pearl would also help facilitate knowledge exchange between communities and partners and synthesise evidence for dissemination through UNEP's Climate, Environment and Security Partnership.

This support would ensure that analytical consistency and learning are maintained between the local and regional components of the UNEP wider transboundary programme. Analytical templates and indicator definitions for monitoring and stress-testing are provided in Appendix A7 (Survey Instruments) and Appendix A9 (Prioritisation Criteria Matrix) to ensure methodological continuity between phases.

6.3 Partnership and governance

Implementation will remain nationally led through LRI's coordination with the Ministries of Agriculture, Environment, and Energy and Water, with municipal authorities. Subject to funding, The Pearl would be happy to participate in an advisory committee to provide technical input, review progress and help manage analytical and conflict-sensitivity risks.

This collaborative model mirrors the Phase I approach, which proved effective for rapid delivery and trust-building. Governance arrangements and risk-management procedures are further detailed in Appendix A8 (Political and Security Assessment).

6.4 Monitoring, evaluation and learning

Pending funding, The Pearl would work with LRI to refine the MEL framework during the first quarter of the Phase II, focusing on knowledge gains, changes in farming practice, water access and early livelihood impacts. The MEL plan should integrate stress-testing results to ensure that adaptation measures remain robust under changing climatic and socio-economic conditions. Regular joint reviews would help feed lessons back into implementation and inform national adaptation planning, ensuring that emerging insights are captured and shared.

The evolving MEL framework would be annexed to Annex A (Implementation Plan) and periodically updated using field data collected through the community survey instruments in Appendix A7.

6.5 Timeline

Phase II will run from 1 October 2025 to 30 September 2026, following the sequencing shown in **Figure 12** and detailed in Annex A.

Figure 12: Simplified timeline of Phase II activities and deliverables, October 2025 - September 2026. Source: Annex A Implementation Plan.

Milestones correspond to deliverables 1.1 - 1.7 listed in Annex A.

6.6 Link to national frameworks and regional learning

Phase II activities will contribute to implementing Lebanon's National Adaptation Plan and related sectoral strategies, providing a model for neighbouring regions. The evidence and methods from Akkar will feed into UNEP's regional Climate, Environment and Security Partnership, supporting integrated adaptation and peace-building approaches across fragile and transboundary contexts.

Lessons and indicators from Phase II will inform both national and policy dialogues and regional learning. Two planned in 2026-27. Summary indicators are presented in Appendix A9 (Prioritisation Criteria Matrix) and policy insights in Appendix A8 (Political and Security Assessment).

7 CONCLUSIONS

The Akkar pilot demonstrates that rigorous, people-centred adaptation planning is achievable even in fragile and data-limited contexts when scientific analysis and local knowledge are integrated under a single, enabling framework. As outlined in Sections 2 to 5, Phase I successfully combined reanalysis and downscaled projections with participatory consultations, livelihood-zone mapping and structured prioritisation to co-produce a shared understanding of climate risks and practical responses.

The three near-term climate-livelihood storylines, CS1 (Hotter + Rainier), CS2 (Hotter + Irregular Rainfall), and CS3 (Hotter + Drier), capture the range of plausible futures facing Akkar over the next decade. Each highlights a different combination of pressures across water, agriculture and forest sectors, yet all underscore the same core needs: secure water supply, soil and slope protection, efficient irrigation, and resilient crops and livelihoods.

Two methodological choices underpin the project's success. First, embedding ICICLE (Inclusive Consultative Integrated Climate, Livelihoods and Environment) storylines within the ICECCAP enabling environment kept the work decision-centred and implementation-oriented. Second, the hybrid livelihood-zoning process, validated through community engagement, produced spatial evidence that was both trusted and conflict-sensitive. Together these approaches transformed what could have been a narrow technical exercise into an inclusive process for joint learning and planning.

The findings show that adaptation planning grounded in real-world experience can strengthen both resilience and social cohesion. The next phase, led by the Lebanon Reforestation Initiative with continued technical support from The Pearl and oversight from UNEP West Asia, will put these insights into practice through a local agricultural adaptation strategy, pilot nature-based interventions, and continued scenario stress-testing.

Beyond Akkar, the approach offers a replicable model for integrated adaptation planning across Lebanon and the wider region. It demonstrates how data, dialogue and decision-making can reinforce one another, turning scientific evidence into action, and local initiative into regional cooperation for peace and resilience.

Annex A (Implementation Plan) sets out how these insights will be translated into action through Phase II activities led by LRI, with technical support from The Pearl subject to funding, and oversight by UNEP West Asia.

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APPENDICES

A1 LEBANON BACKGROUND

This appendix provides contextual information on Lebanon's physical, socio-economic and institutional setting to complement the overview in Section 1.

A1.1 Physical geography and climate setting

Lebanon occupies a narrow corridor between the Mediterranean Sea and the Anti-Lebanon Mountains, covering 10,452 km² with a population of about 5.3 million (World Bank 2024). Its steep terrain creates sharp climatic and ecological contrasts over short distances: a humid coastal plain, two mountain ranges rising above 3,000 m, and an arid interior plateau.

The country experiences a Mediterranean climate, characterised by long, dry summers and short, wet winters. Rainfall decreases sharply from the coast to the interior, while temperatures rise toward the Bekaa and northern plains. Groundwater occurs mainly within karstic (limestone) aquifers, where infiltration and storage are highly variable, making water supply unpredictable between wet and dry seasons.

These physical features shape local climate variability and underpin the data analysis presented in Appendix A2.

A1.2 Climate and environment

This section provides only a brief national overview of Lebanon's climate and key environmental trends; detailed quantitative analysis is presented in Section 2 of the main report.

Lebanon's climate is typically Mediterranean, with cool, wet winters from December to March, and hot, dry summers from June to September. Average annual rainfall ranges from 800 to 1,000 mm along the coast, rising to more than 1,400 mm in the mountains and falling below 400 mm in the interior Bekaa valley. These strong climatic gradients underpin the country's ecological and agricultural diversity.

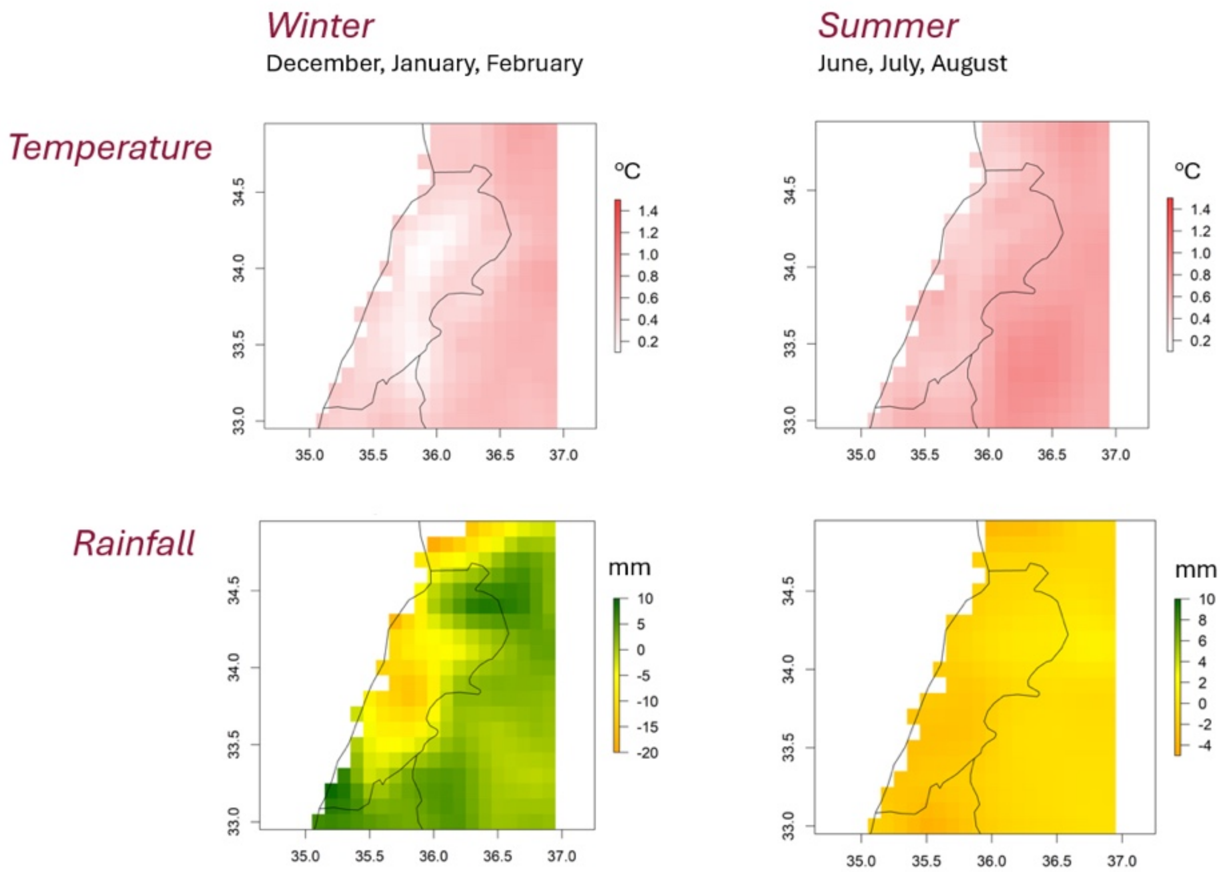

Figure 13: Observed temperature (top) and rainfall (bottom) anomalies for winter (left) and summer (right) anomalies, 1991-2020. Source: Walker Institute (2025), slides for Akkar Workshop (April 2025).

National analyses based on ERA5 reanalysis and LARI national station data confirm a steady warming trend of +0.2 to +0.3 °C per decade since the 1970s and a 10-15 % decline in mean annual rainfall (Walker Institute 2025; Pino Delgado 2025) (**Figure 13**). Heatwaves are becoming longer, droughts more frequent, and wildfires more widespread, particularly in the northern mountains (El-Hajj et al., 2015; Dagher et al., 2021).

These national patterns underpin the more detailed regional analysis for Akkar presented in Section 2 and Appendix A2.

A1.3 Water resources and management

Lebanon's hydro-geology is dominated by a dense karstic system, meaning that soluble limestone and dolomite rocks have formed extensive underground channels and springs that store and convey groundwater. This system is fed by snowmelt with many springs and short, steep rivers, yet summer water shortages are widespread. Major rivers, the Litani, Orontes (Assi), and Kabir, originate in the mountains and drain westward to the sea or eastward into Syria. Despite relatively high rainfall, water scarcity is acute in summer because of poor storage and aging infrastructure. Roughly half of the available surface water is lost through leakage or evaporation before use (NWSS 2020).

Groundwater from over 80,000 unregulated wells supplies more than 60 percent of domestic use. Quality is declining because of wastewater leakage and fertiliser run-off (Dagher et al., 2021; El Chamieh et al., 2024). Responsibilities are divided among the Ministry of Energy and Water, regional Water Establishments and municipalities, slowing implementation of the National Water Sector Strategy (NWSS 2020) targets.

The implications of these constraints for local adaptation planning in Akkar are discussed in Section 2.1 and 3.4.

Table 2: Major river basins and aquifers of Lebanon. Source: Shaban (2021); NWSS (2020).

	River name	Type of River	Length (km)	Catchment area, A, (km^2)	Rainfall R (millions of m^3 yr^{-1})	Discharge D (millions of m^3 yr^{-1})	R/A (millions of m^3 km^{-2}yr^{-1})	D/R (%)
1	El-Kabir River	Inner	46	303	260	222	0.38	transboundary
2	El-Bared River	Coastal	37	284	225	165	0.79	73
3	Abou-Ali (Kadisha) River	Coastal	42	482	505	365	1.04	72
4	El-Jaouz (Kfarhelda) River	Coastal	33	196	125	80	0.64	64
5	Ibrahim (Abraham) River	Coastal	44	336	380	495	1.16	131
6	El-Kaleb River	Coastal	35	237	330	225	1.39	66
7	Beirut River	Coastal	48	216	260	100	1.20	38
8	El-Damour River	Coastal	45	333	335	255	1.00	76
9	El-Awali River	Coastal	50	291	320	280	1.09	88
10	Siniq River	Coastal	18	102	100	60	0.98	60
11	El-Zahrani River	Coastal	36	140	145	200	1.03	137
12	Litani River	Inner	163	2,110	2,078	360	0.98	17
13	Al-Assi (Orontes) River	Inner	31	1,930	1,254	420	0.65	transboundary
14	Hasbani-Wazzani River	Inner	22	645	598	225	0.65	transboundary

A1.4 Agriculture, forestry and livelihoods

Agriculture provides 3 to 4 percent of GDP and around 20 percent of employment (MoA 2022). Most farms are small family holdings averaging 1.4 ha (WB 2023). Main crops include olives, citrus, apples, potatoes and tobacco; livestock herding (sheep and goats) is important in the dry uplands.

The 2019 economic collapse increased fuel and input costs, reducing cultivated areas (see **Figure 14**) and prompting greater forest use for firewood. Lebanon's forest cover is about 13 percent of land area, and declining (El-Hajj et al., 2015). Rural households depend more on remittances and informal work (ESCWA 2023). Women now play larger roles in farm management and decision-making (Nasser and Abbas 2022).

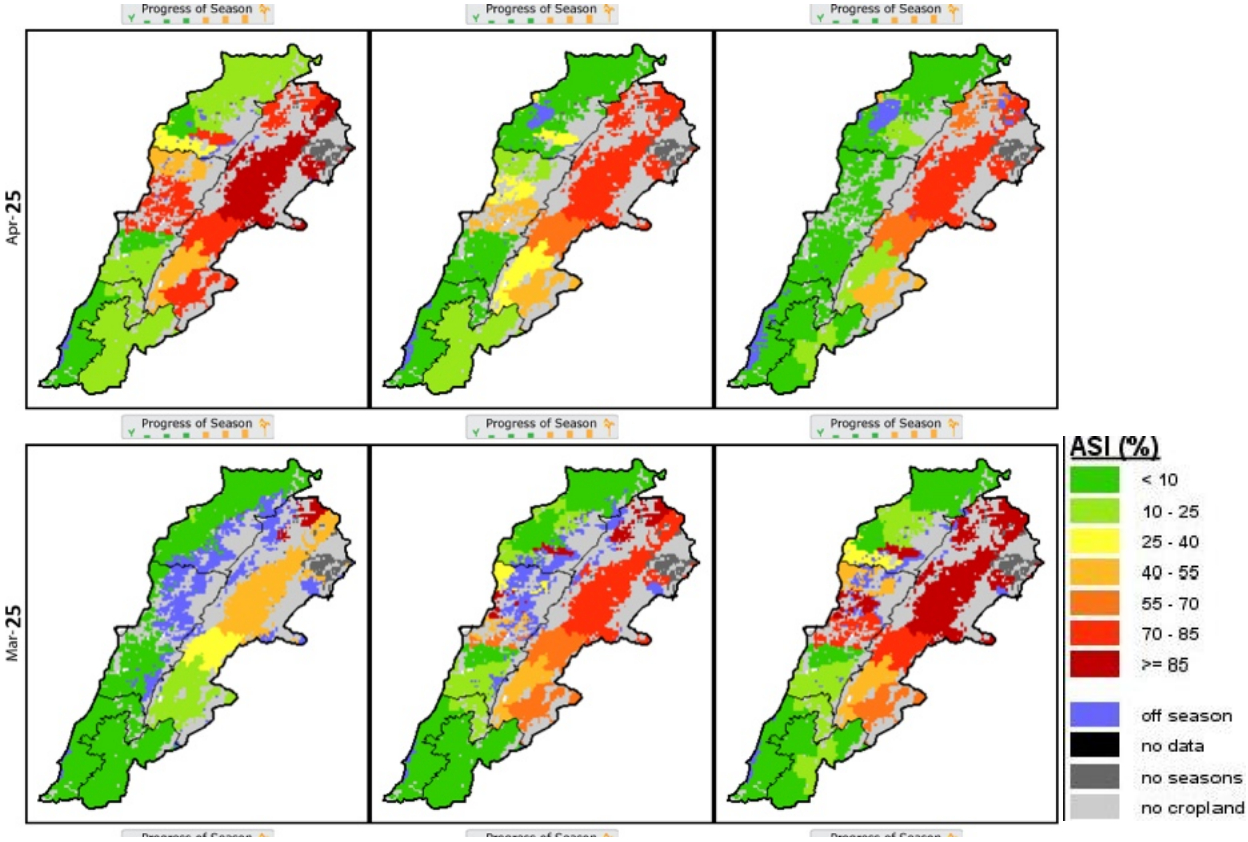

Figure 14: FAO agricultural stress index maps of Lebanon. Source: FAO GIEWS Earth Observation Platform https://www.fao.org/giews/earthobservation/country/index.jsp?lang=en&code=LBN# (accessed 24 Oct 2025)

The next subsection summarises how these pressures manifest most acutely in Akkar Governance.

A1.5 Environmental and socio-economic pressures in Akkar

Akkar Governorate combines high ecological diversity with Lebanon's highest poverty levels. About 63 % of households live below the national poverty line (UNDP 2022). Farming is small-scale and labour-intensive; deforestation, erosion and wildfires are widespread (LRI 2025). Water scarcity and waste dumping on steep slopes exacerbate land degradation. As one farmer in Sfaynet Qaitaa, "*The rains now come late and stop too soon; we can't plan the harvest any more*".

Migration has reshaped local rural demographics. Many younger men work in Tripoli or abroad, leaving women and older farmers to manage land. Refugee settlements have increased pressure on water and fuelwood supplies and occasionally trigger local disputes (UNHCR 2024). Municipalities have limited capacity to coordinate environmental management across administrative boundaries.

These realities highlight the intersection of environmental and social stressors that the Akkar pilot sought to address.

A1.6 Policy and institutional framework

The National Adaptation Plan (NAP) (MoE 2023) prioritises agriculture, water, forests, coastal zones and health. Implementation has been limited by fiscal constraints and overlapping mandates among the Ministries of Environment (MoE), Agriculture (MoA), and Energy and Water (MoEW). Municipal engagement in adaptation is increasing but uneven.

The National Biodiversity Strategy (2020) and National Reforestation Plan (2015) aim to restore ecosystems. The National Water Sector Strategy (NWSS 2020) focuses on storage and wastewater treatment. Donor programmes by the EU, UNEP and USAID provide support but remain project-specific and fragmented (UNEP 2023). Akkar has little representation in national planning, underlining the need for local adaptation strategies.

A1.7 Relevance to the Akkar pilot

The conditions described above explain the choice of Akkar (**Figure 15**) as the pilot governorate for community-based adaptation under the EU-UNEP Climate Change, Environment and Security Partnership. Akkar illustrates how climate stress, ecological degradation and livelihood fragility intersect in vulnerable landscapes. Its border location and resource competition make it a relevant setting for testing adaptation approaches that also contribute to peace and stability.

Figure 15: View of a valley in Akkar (LRI team)

Lessons from Akkar demonstrate how scientifically informed yet locally led planning can deliver credible, inclusive adaptation pathways that are replicable across Lebanon and the wider region.

This contextual analysis underpins the scientific evidence and methods presented in Sections 2 and 3 of the main report.

A2 CLIMATE DATA AND ANALYSIS

This appendix provides supplementary technical details on the data, methods and diagnostics used for the observed trend and near-term projection analyses summarised in Section 2 of the main report.

A2.1 Datasets and sources

The climate analysis drew primarily on combined reanalysis, observation and model data to ensure consistency across spatial and temporal scales.

Table 3: Primary datasets and sources used for the Akkar climate analysis

Dataset	Period	Resolution / Coverage	Source
ERA5 & ERA5-Land	1979 - 2024	≈ 0.1° (~ 9 km) global	ECMWF / Copernicus Climate Data Store
LARI station data	1980 - 2024	4 stations across Lebanon	Lebanese Agricultural Research Institute (LARI)
CMIP6 ensemble (9 models)	2025 - 2035	1° → statistically downscaled to 0.25° (≈ 25 km)	CEDA Archive
Strata.EarthMap	Current	≈ 5 km visual layer portal	FAO / GEO portal
Global Forest Watch	2000 - 2024	30 m tree-cover loss and fire data	World Resources Institute
Copernicus DEM	-	25 m digital elevation model	ESA / Copernicus

All datasets were regridded to a common 10 km spatial resolution and processed in Python 3.11 and R 4.3 following Wells et al. (2023).

A2.2 Analytical methods and diagnostics

To limit the number of CMIP6 models used in the project, a literature review of downscaled models was carried out. Nine CMIP6 models were identified that consistently reproduce past climatic conditions in the MENA region with a reasonable degree of accuracy: CESM2, GFDL-ESM4, HadGEM3-GC31-LL, IPSL-CM6A-LR, MIROC-ES2L, MPI-ESM1-2-LR, MRI-ESM2-0, NorESM2-MM and UKESM1-0-LL.

Temperature and precipitation (rainfall) output from the CMIP6 models for the Akkar region were compared to downscaled ERA5 reanalysis data (1984-2014) that had been adjusted to match the spatial-temporal resolution of the downscaled CMIP6 models. Reanalysis data were used as a proxy for observations because reliable long-time series for Akkar were not available.

Standard statistical diagnostics (bias, RMSE, correlation, variance ratio, Kling-Gupta efficiency, tail ratios and confidence intervals of the trends for trend preservation) were applied to check consistency, validate the CMIP6 model output and carry out seasonal checks. These diagnostics indicated that model accuracy could be enhanced by bias correction (BC) to better reflect the effects of Akkar's topography on local climate. **Figure 16** shows model performance before the bias correction, and **Figure 17** after bias correction.

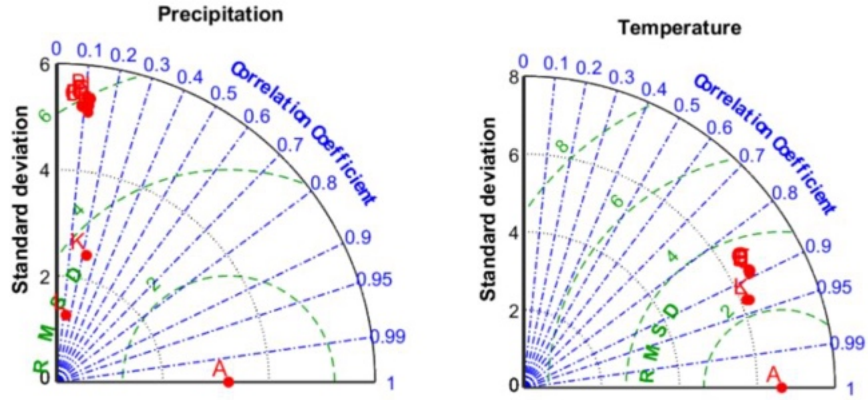

Figure 16: Taylor Diagrams showing correlation coefficient (blue), standard deviation (black), and root mean square deviation (green) between models and observations in Akkar *before bias correction* for CMIP6 precipitation and temperature historic datasets (1984-2014). Point A = perfect match; L= ensemble mean; K = ensemble median; remaining points correspond to the nine individual models. Source: Pino Delgado (2025).

Bias corrected CMIP6 models under SSP5-8.5 scenario were then used to derive near-term climate storylines.

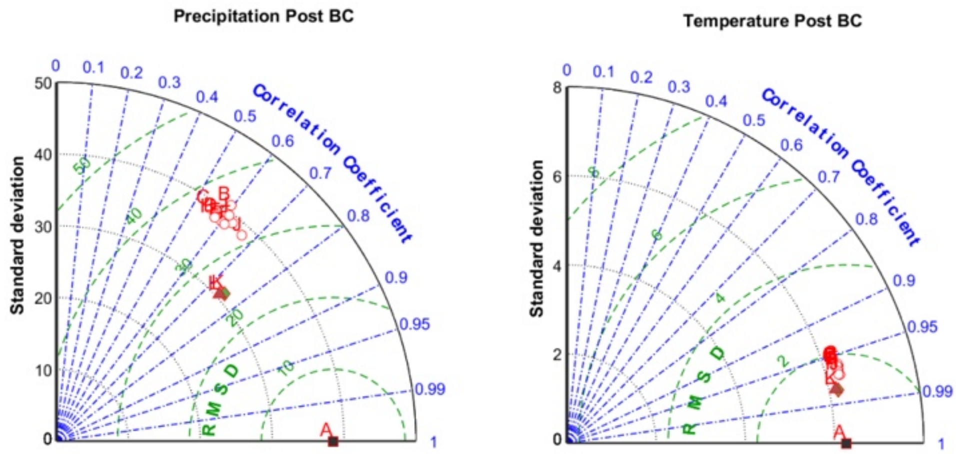

Figure 17: As **Figure 16**, but *after bias correction* for CMIP6 precipitation and temperature historic datasets (1984-2014). Source: Pino Delgado (2025).

A2.3 Past climate and extreme events

Downscaled ERA5 data confirm that temperature in Akkar has been rising progressively over 1984 to 2025 (**Figure 18**) at *+0.6 °C per decade* which is higher than the national mean warming rate given in Section 2.1 (*+0.2 to +0.3 °C per decade)*. There is no clear long-term trend in precipitation; the seasonal cycle of rainfall persists (**Figure 19**).

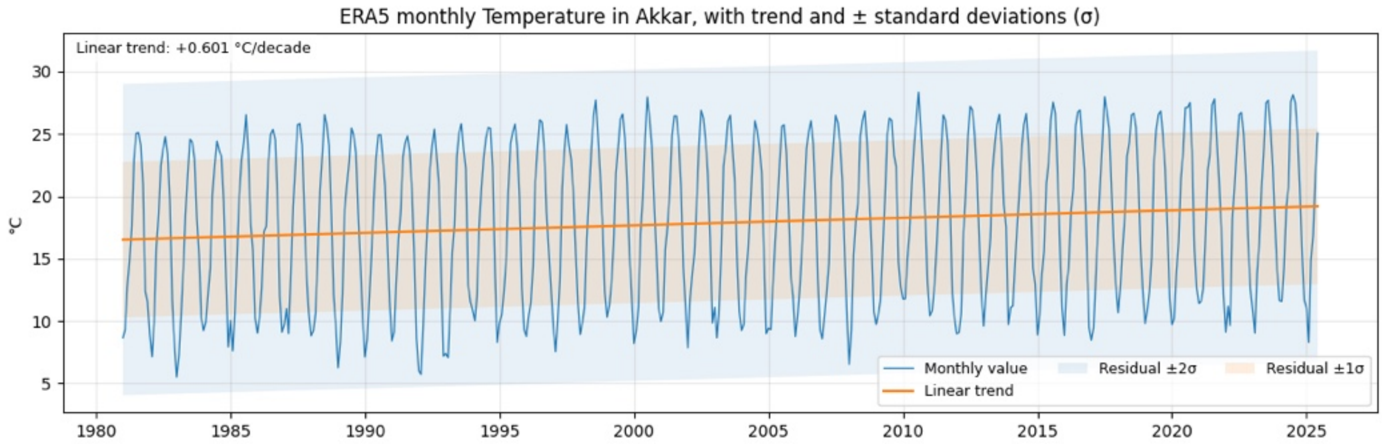

Figure 18: ERA5 monthly temperature in Akkar, from 1981 to 2025. A positive trend of +0.6 °C is noticeable. Source: Pino Delgado (2025).

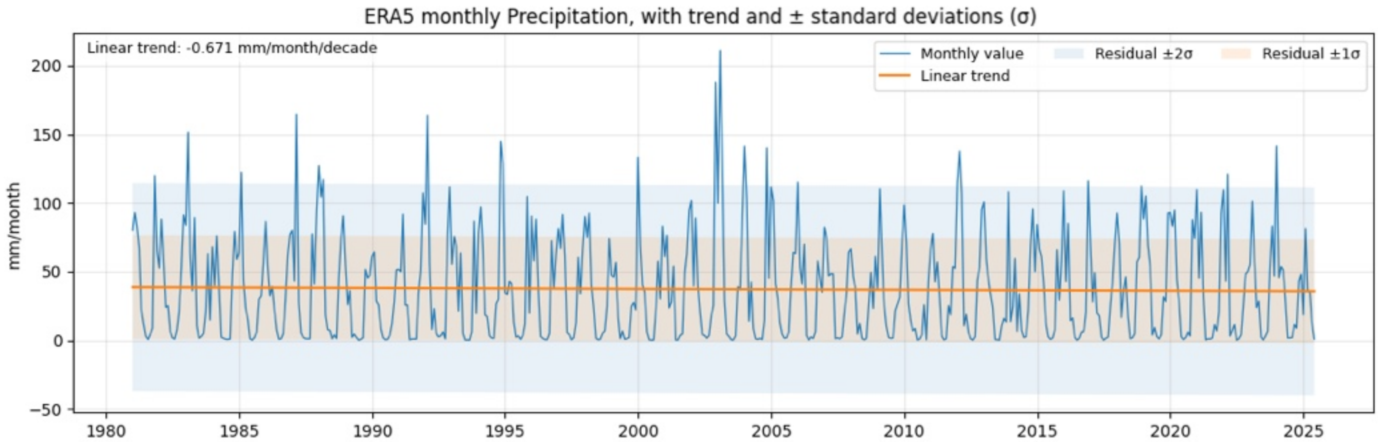

Figure 19: ERA5 monthly precipitation, from 1981 to 2025. Source: Pino Delgado (2025).

A2.4 Agro-climatic indices

To identify extreme conditions in Akkar, percentile thresholds were derived from the monthly ERA5 baseline (1985-2014):

- Temperature: P10/P20 (cold), P80/P90 (hot)
- Precipitation: P20/P10 (dry), P80/P90/P95 (rainy)

These match locals' concerns about the impact cold winters, hot summers and dry conditions interspersed with very wet conditions have on their livelihoods.

A2.5 Identifying three distinct near-term (2025-2035) storylines

Outputs from the nine CMIP6 models were grouped based on projected changes in temperature (ΔT) and precipitation (ΔP) relative to 1985-2014 (baseline) (**Figure 20**). Relative humidity was examined but, as it was less significant, is not shown here.

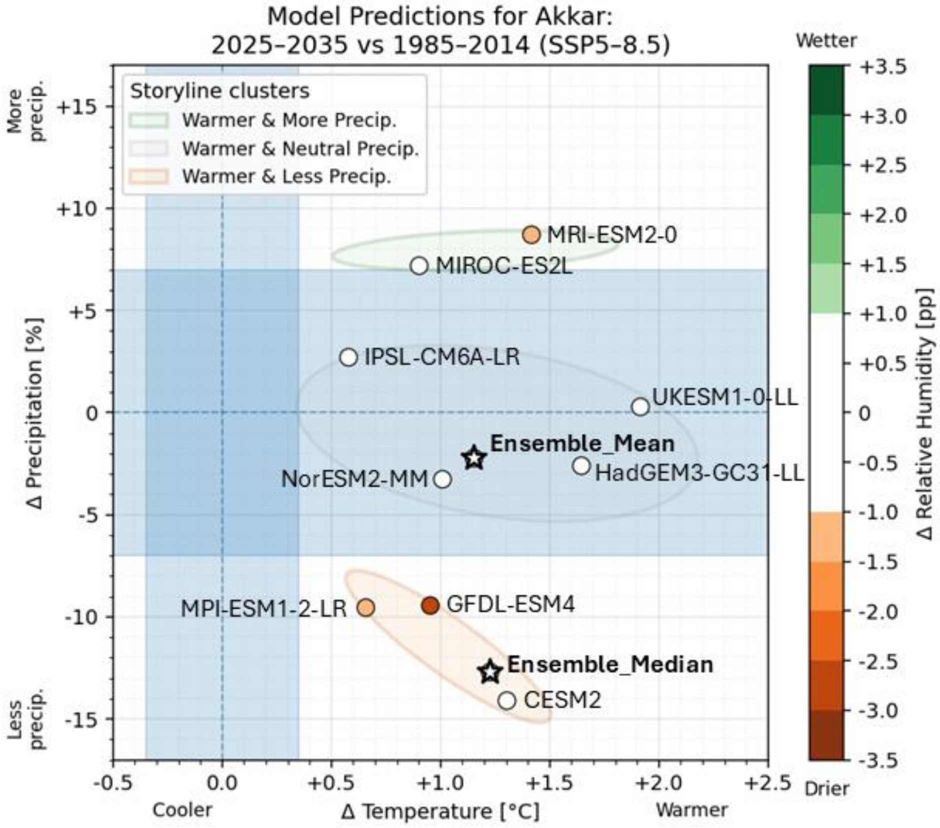

Figure 20: Three near-term climate storylines for Akkar (CS1 - Hotter + Rainier; CS2 - Hotter + Erratic Rainfall; CS3 - Hotter + Drier). Source: Pino Delgado (2025).

Figure 20 shows the three distinct near-term (2025-2035) storylines. These are:

CS1. Hotter and wetter - modest warming and an increase in cool-season precipitation (2 models).
CS2. Hotter and irregular precipitation - warming with little change in annual totals but pronounced intra-seasonal swings (5 models).
CS3. Hotter and drier - warming with a decline in cool-season precipitation (4 models)

Each storyline was analysed separately. Differences between them represent model uncertainty; shared signals (commonalities) indicate areas of higher confidence with less uncertainty.

A2.5.1 Storyline commonalities

Common signals across all three near-term storylines include:

Temperature: rising, year-round temperatures, with largest increases from June to September; longer summers; most summers include months exceeding P80. Winters warm less but can include brief sharp falls in temperatures (**Figure 21**).

Precipitation: a slight delay in the onset of the rainy season from September toward October or later; frequent occurrence within the same wet season of both very high precipitation (≥P90) and very dry months (≤P10).

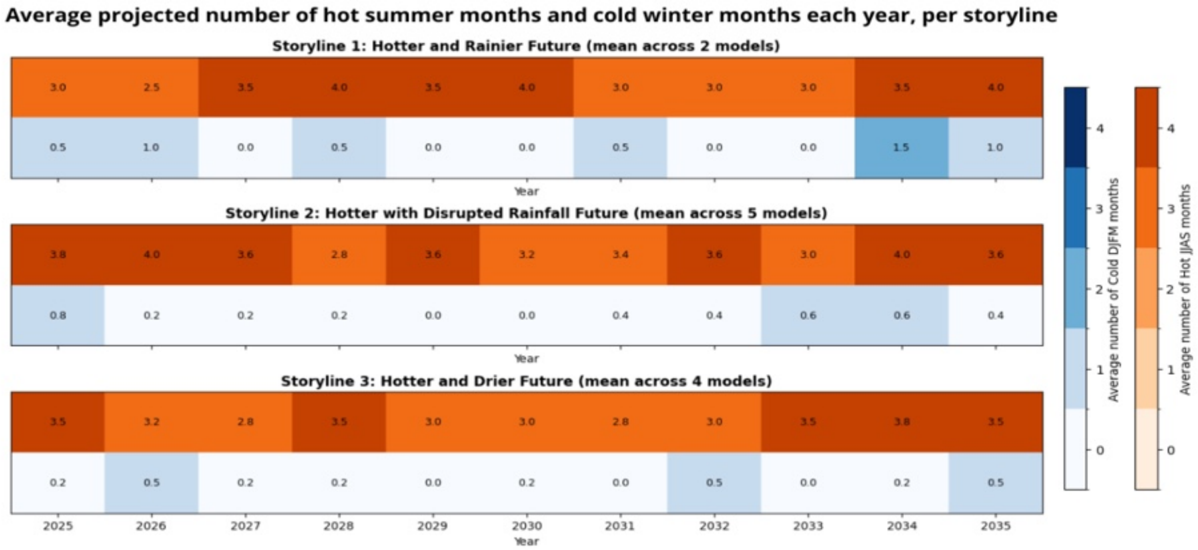

Figure 21: Average projected number of hot summer months (temperatures exceeding the 80th percentile of summer temperatures, >P80) and cold winter months (temperatures below the 20th percentile of winter temperatures, <P20) per year, by storyline. Source: Pino Delgado (2025).

A2.5.2 CS1: Hotter and Wetter

Warming of about +0.9°C to +1.4°C with a +7% to +9% increase in precipitation (**Figure 23**). The dry summer / wet winter regime persists.

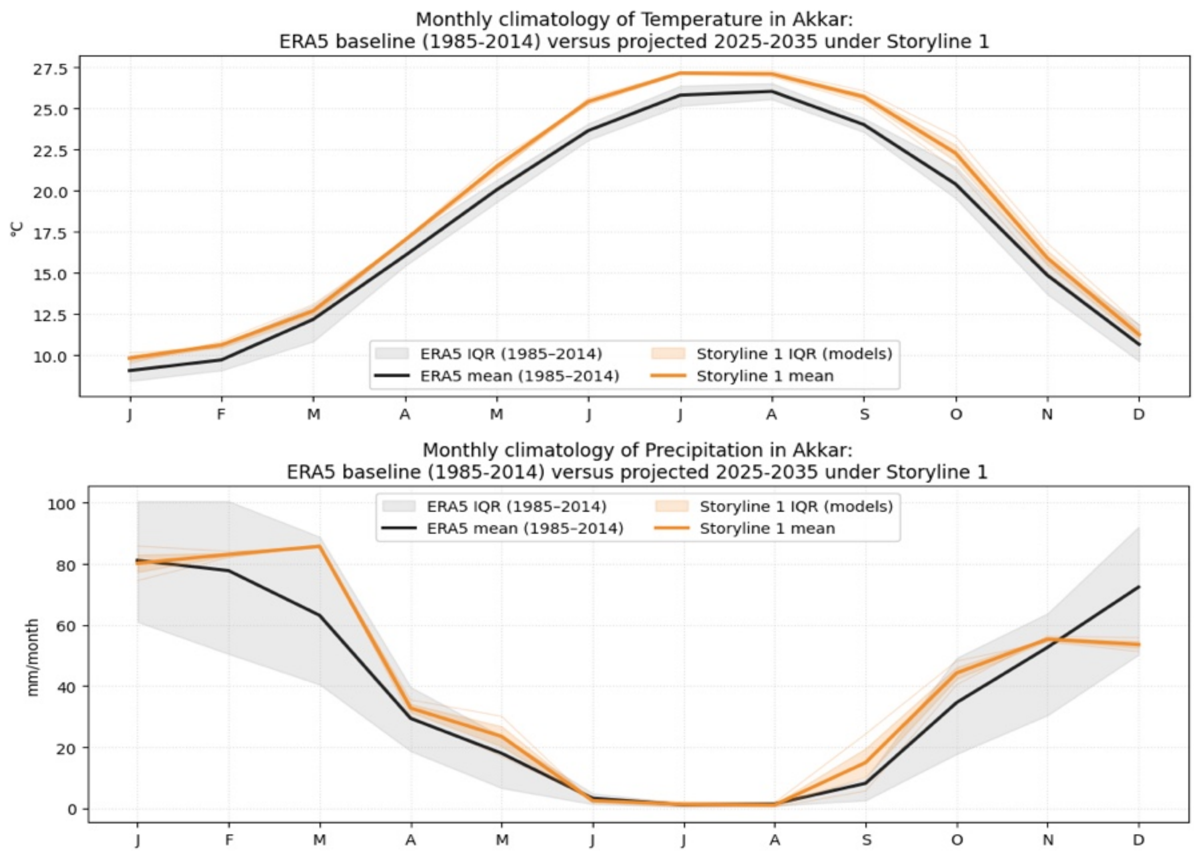

Figure 22: Monthly climatology of temperature (top) and precipitation (bottom) projected for Akkar 2025-2035, versus 1985-2014 (historic baseline), CS1 (Hotter and Wetter). Source: Pino Delgado (2025).

Summers become hotter and longer, with July and August-like conditions extending from June to mid-September, increasing heat stress on crops and labour. Occasional cold winter months remain possible (**Figure 24),** with several models indicating cold-month occurrences in winters (temperatures < P20 of winter temperatures) in years 2026, 2034 and 2035. These cold snaps, though less frequent, could threaten sensitive crops, disrupt planting or damage orchards.

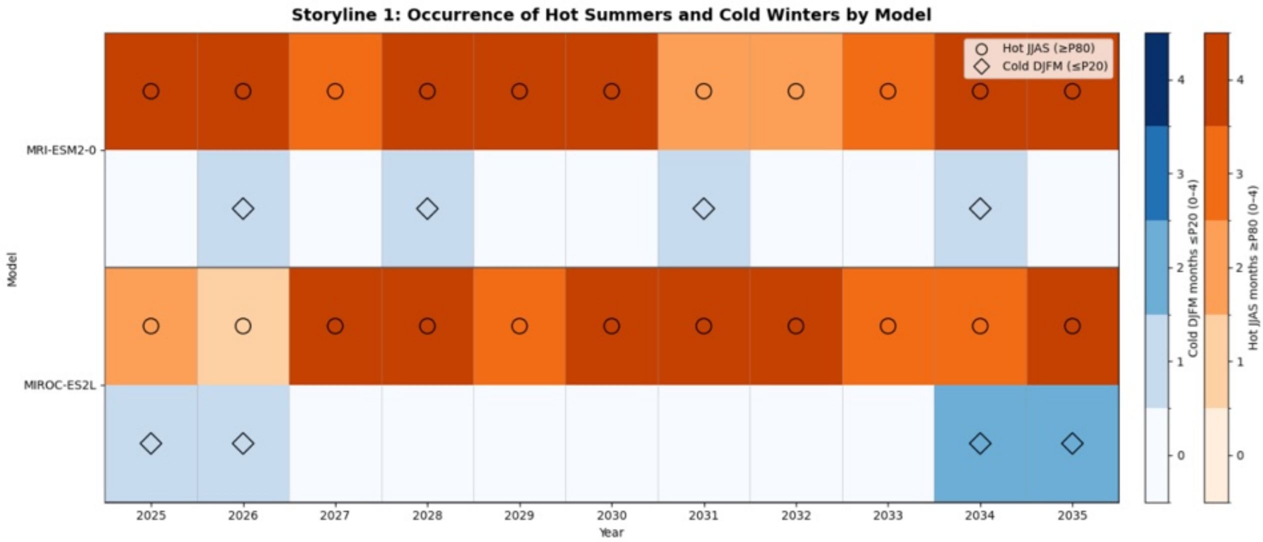

Figure 23: Average projected number of hot summer months (temperatures exceeding the 80th percentile of summer temperatures, >P80) and cold winter months (temperatures below the 20th percentile of winter temperatures, <P20) per year, by storyline. Source: Pino Delgado (2025).

Wet-season rainfall is unevenly distributed. Very wet months (≥P90) occur in most years, while roughly half the wet-season months can be very dry (≤P10) (**Figure 24**). This increases intra-seasonal variability, which aligns with farmer reports of unpredictable rainfall. Flood risk rises in the wet season; short dry spells can interrupt soil-moisture recharge making water management more challenging. The onset of the rain season may be delayed from October to November or December.

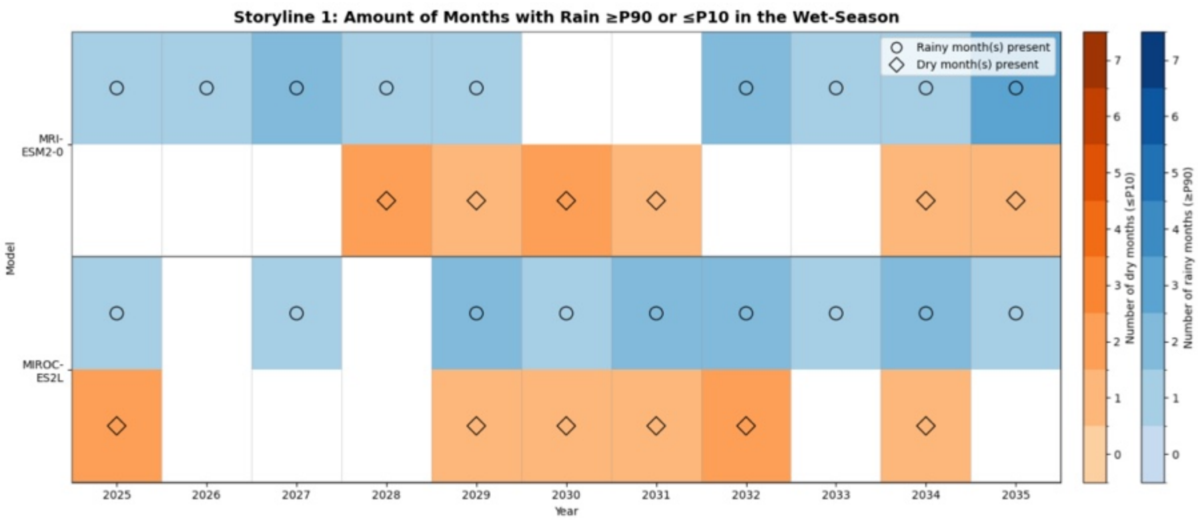

Figure 24: Average projected number of very wet months (> P90) and very dry months (< P10) during the wet season per year, CS1. Source: Pino Delgado

A2.5.3 CS2: Hotter and Irregular Rainfall

Warming of about +1 to +3 °C with little change in annual precipitation (**Figure 25**).

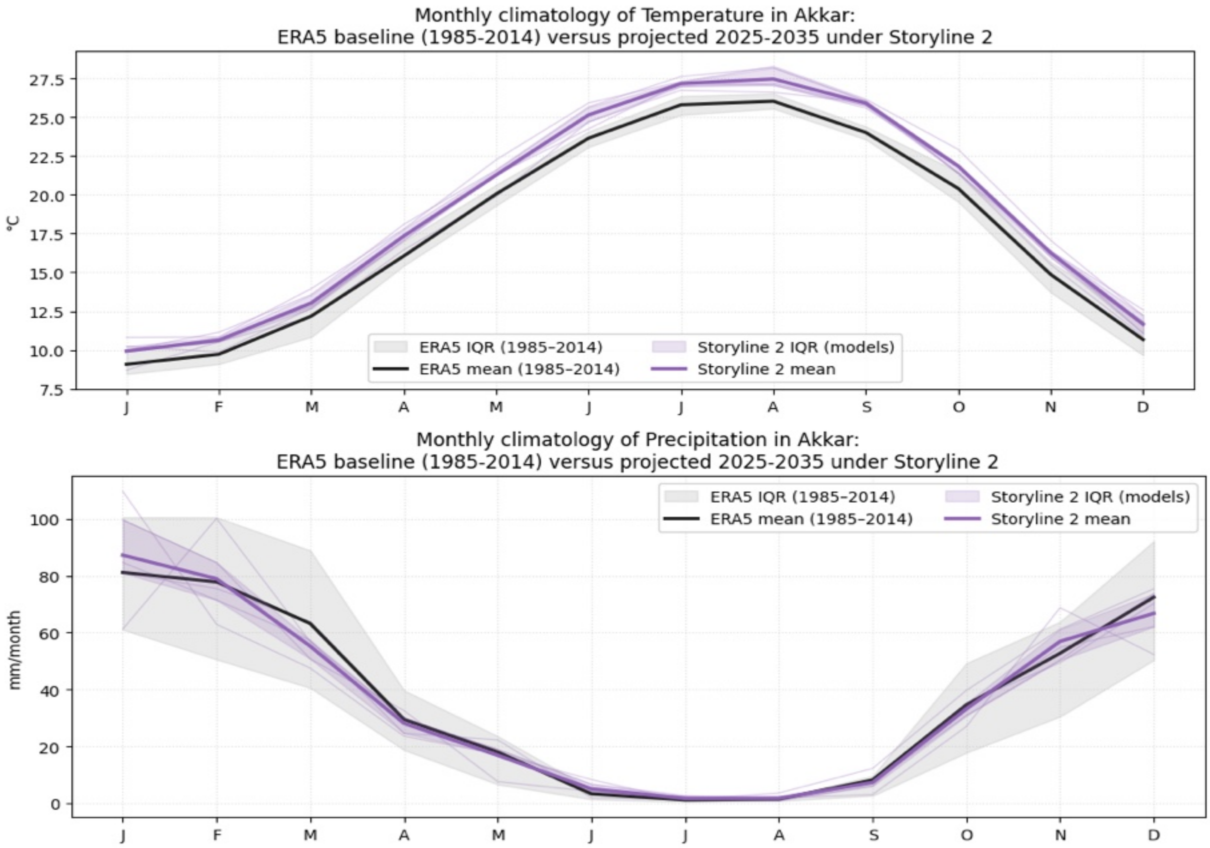

Figure 25: Monthly climatology of temperature (top) and precipitation (bottom) for 2025-2035 vs 1985-2014, CS2 (Hotter + Irregular Rainfall). Source: Pino Delgado (2025).

Summers lengthen and intensify; most summers have months > P80 (**Figure 26**), with some peaking at about +4 °C above historical norms. Winters can include sharp, short-lived cold spells with farmers facing sudden winter freezes that could disrupt crop cycles and damage sensitive plants.

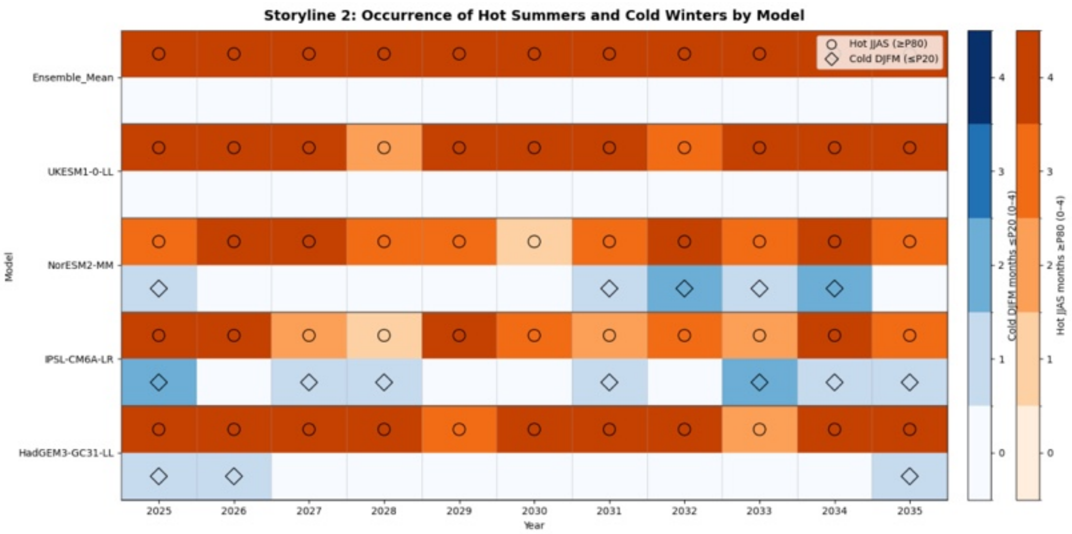

Figure 26: Average projected number of hot summer months (> P80) and cold winter months (< P20) per year, CS2. Source: Pino Delgado (2025).

Although annual totals change little, wet-season rainfall is sporadic and volatile: nearly every year includes at least one very wet month (≥ P90) and one very dry month (≤ P10) (**Figures 26 and 27**) with farmers facing issues of flooding and water-logging, followed by very dry soil. Wet-season onset can be delayed to November, partly compensated by more intense rainfall later.

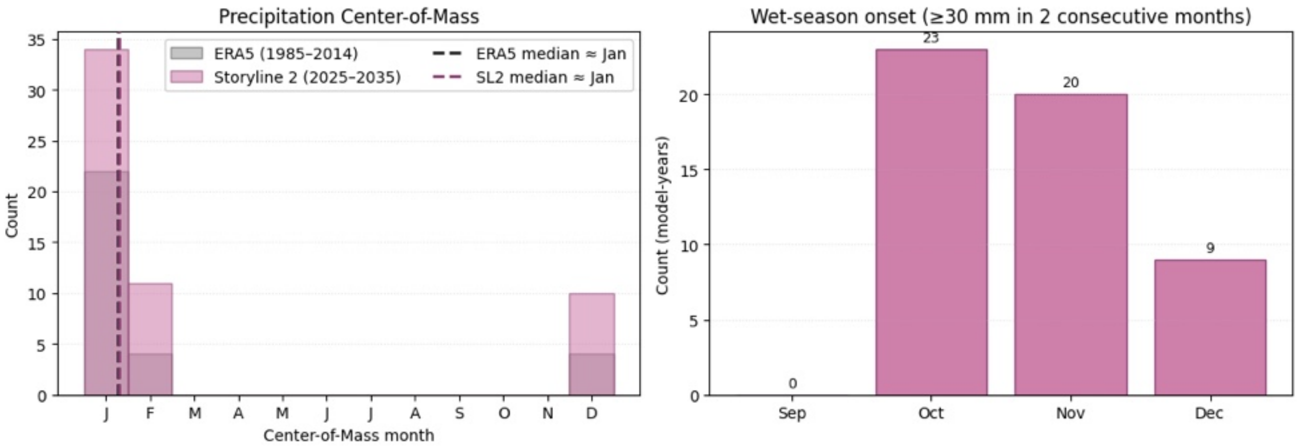

Figure 27: Wet-season timing diagnostics for CS2: precipitation centre-of-mass (left) and onset (right). Source: Pino Delgado (2025).

Although annual totals change little, wet-season rainfall is sporadic and volatile: nearly every year includes at least one very wet month (≥ P90) and one very dry month (≤ P10) (**Figure 28**). Wet-season onset can be delayed to November, partly compensated by more intense rainfall later.

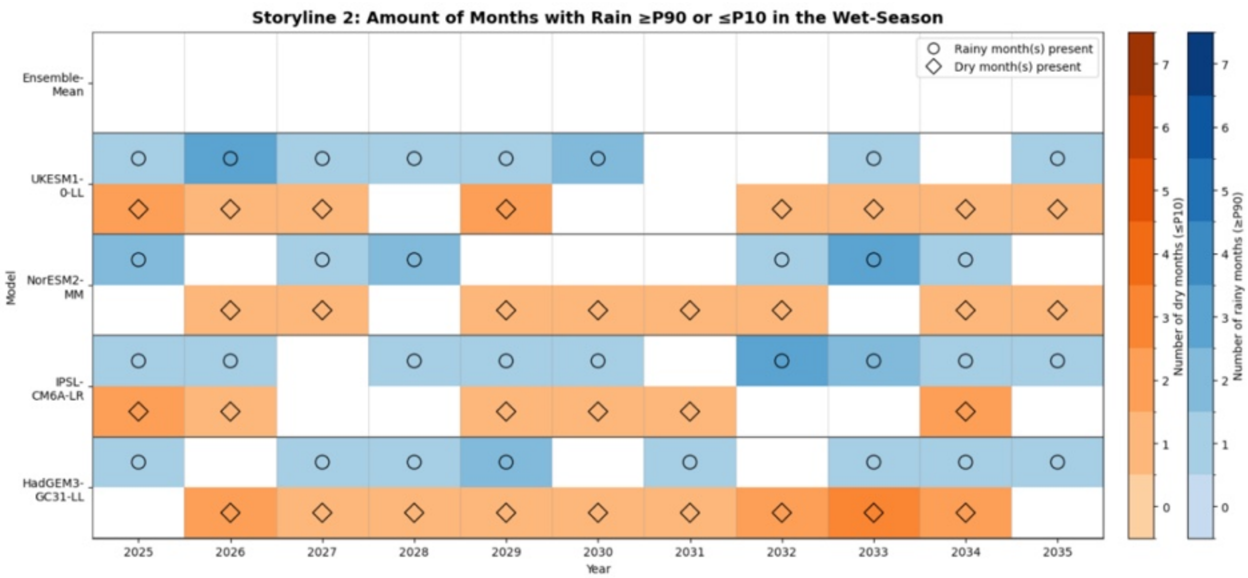

Figure 28: Average projected number of very wet months (≥ P90) and very dry months (≤ P10) during the wet season per year, CS2. Source: Pino Delgado (2025).

A2.5.4 CS3: Hotter and Drier

Warming of about +0.5 to +2 °C with a −9 to −14 % change in precipitation (**Figures 29** and **30**).

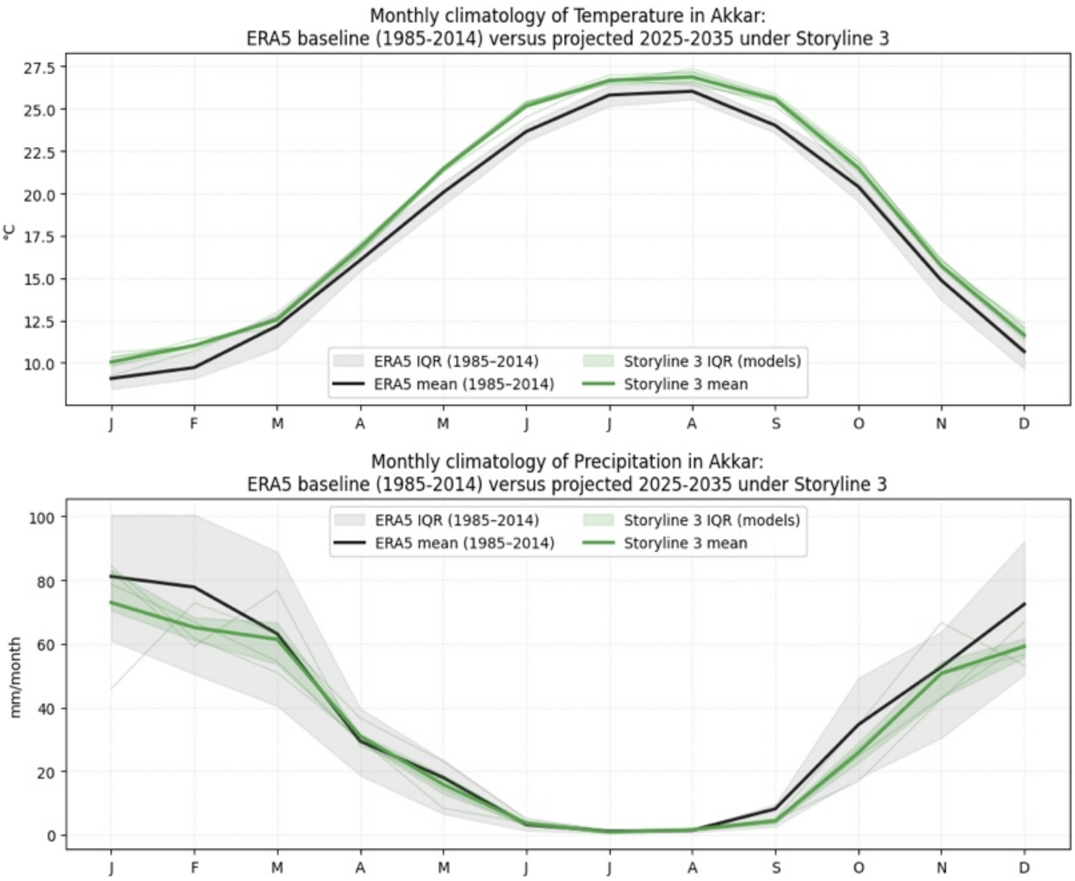

Figure 29: Monthly climatology of temperature (top) and precipitation (bottom) for 2025-2035 vs 1985-2014, CS3 (Hotter + Drier). Source: Pino Delgado (2025).

Summers are consistently hotter and longer. In most years at least three core summer months exceed P80 (**Figure 30**). Despite the dominant warming, occasional cold winter months (< P20) still occur that could damage sensitive crops and disrupt planting cycles.

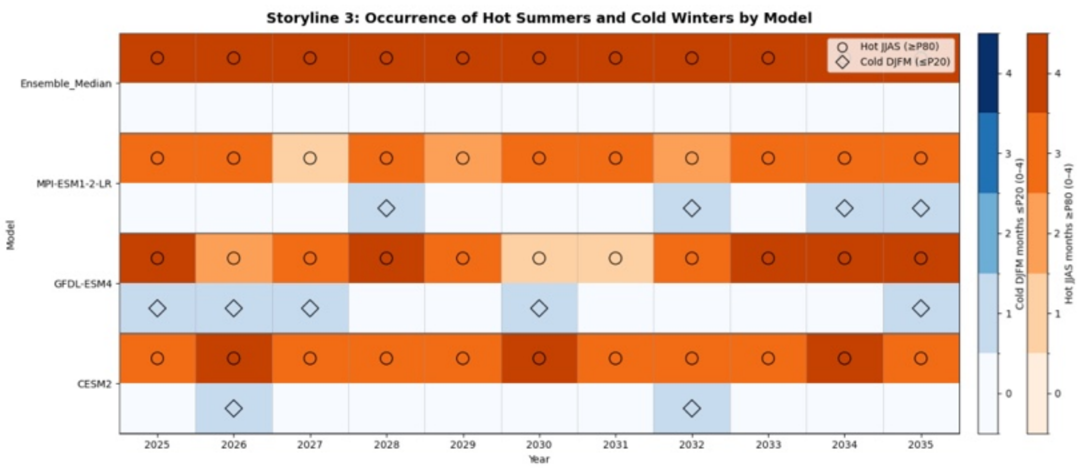

Figure 30: Average projected number of hot summer months (> P80) and cold winter months (< P20) per year, CS3. Source: Pino Delgado (2025).

Rainfall decline is concentrated in frequent cool-season shortfalls; summers remain dry. Wet-season onset often shifts to November or December, increasing pressure on storage and irrigation. Very wet months (≥ P90) still occur, interspersed with very dry months (≤ P10), sometimes within the same season (**Figure 31**), raising both flood and water-stress risks and heightening uncertainty for farmers who must respond to these shifting conditions.

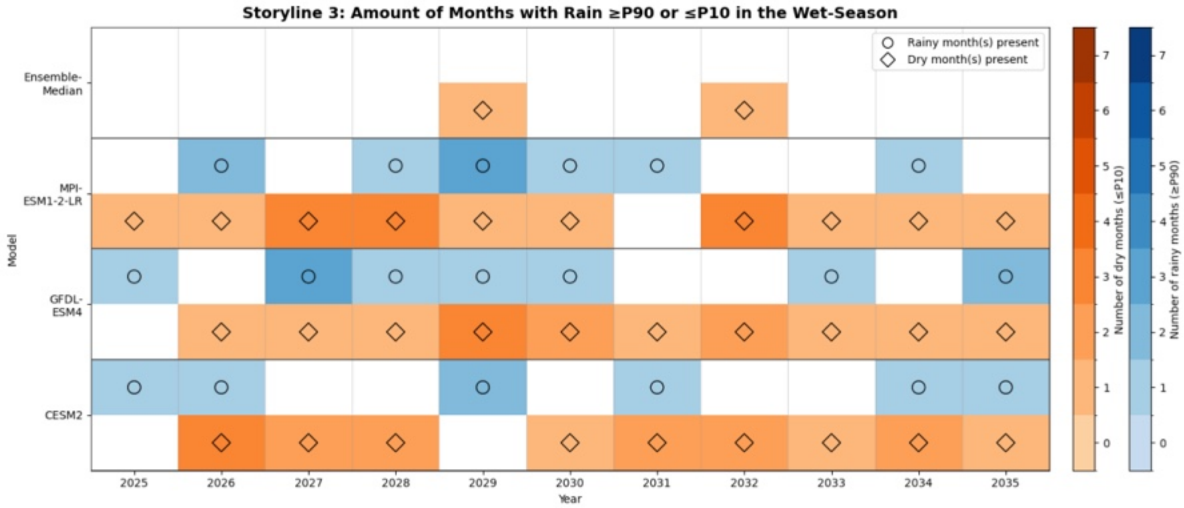

Figure 31: Average projected number of very wet months (≥ P90) and very dry months (≤ P10) during the wet season per year, CS3. Source: Pino Delgado (2025).

Overall, CS3 describes longer, hotter summers, shorter and less reliable rainy seasons and greater volatility in cool months. Farmers face persistent summer heat, delayed rains and alternating wet-dry extremes that challenge water management and cropping calendars.

A2.6 Uncertainty and limitations -The ICECCAP-ICICLE methodology

Uncertainty in climate projection arises from model structure, parameterisation and limited local data, with rainfall showing the greatest spread. Ensemble averaging reduces, but cannot remove, error propagation. The ICECCAP framework applied here provides a way to make these uncertainties explicit, ensuring that adaptation planning remains transparent and decision-centred (Wells et al. 2023).

Within ICECCAP's enabling environment (**Figure 32**), climate analysis is treated not as a technical endpoint but as one strand of a wider system linking governance, resources and knowledge. The approach embeds climate information within practical decision contexts, emphasising how analytical confidence, institutional capacity and social legitimacy must evolve together to support implementation.

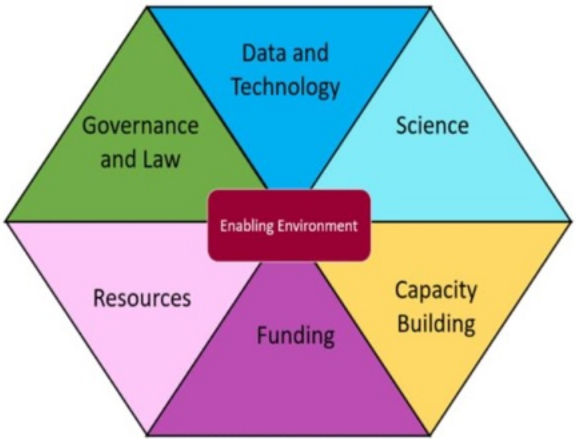

Figure 32: Elements of the ICECCAP enabling environment. Source: Wells et al. (2023).

The Inclusive Consultative Integrated Climate, Livelihoods and Environment (ICICLE) framework complements ICECCAP by integrating physical climate evidence with environmental and socio-economic conditions that shape vulnerability and resilience. Each ICICLE storyline combines a plausible near-term climate trajectory with the contextual drivers that determine local impacts, such as population pressure, land use, migration and market access. By doing so, ICICLE translates complex model outputs into narratives that are intelligible to practitioners and communities while remaining scientifically grounded.

This dual-framework approach allows planners to identify “no-regrets” actions - interventions that are beneficial under multiple futures - and to adopt a Dynamic Adaptive Policy Pathways (DAPP) perspective, adjusting strategies as real-world climate and socio-economic trends unfold. It also provides a structure for communicating uncertainty without paralysing decision-making: rather than predicting a single outcome, it explores several plausible futures that together define a robust space for action.

In this sense, the ICECCAP-ICICLE methodology represents a shift from climate prediction to risk navigation. It encourages iterative learning, continuous monitoring and the integration of local knowledge into every stage of planning. By combining rigorous analysis with inclusive participation, it builds the transparency and trust required for adaptation decisions in complex and data-limited settings.

Further details on the application of these frameworks to Akkar are presented in Sections 3-5 of the main report, and in Wells et al. (2023).

A3 LIVELIHOOD ZONE DESCRIPTIONS AND MAPS

This appendix summarises the livelihood systems of the seven municipalities in the Union of Jerd el Kayteh and the methods used to delineate and validate the livelihood zones shown in Section 3.3 of the main report. These zones form the link between the scientific climate analysis (Appendix A2) and the community priorities identified through the consultations (Appendix A4). Understanding how livelihoods, land use and climate exposure vary spatially across Akkar is essential for designing equitable, conflict-sensitive adaptation measures.

A3.1 Approach and classification

Livelihood zones in Akkar Governorate (**Figure 33**) were delineated through a combined analytical and participatory process led by The Pearl (formerly the Walker Institute) and the Lebanon Reforestation Initiative (LRI). Remote-sensing data (land cover, vegetation indices, elevation, and slope) were integrated with socio-economic and land-use information from municipal records and field surveys. The resulting draft classification was validated through key-informant interviews and local consultation meetings between January and April 2025. This analysis corresponds to the participatory mapping described in Section 3.3 and provides the spatial basis for the prioritisation of adaptation measures in Section 3.4.

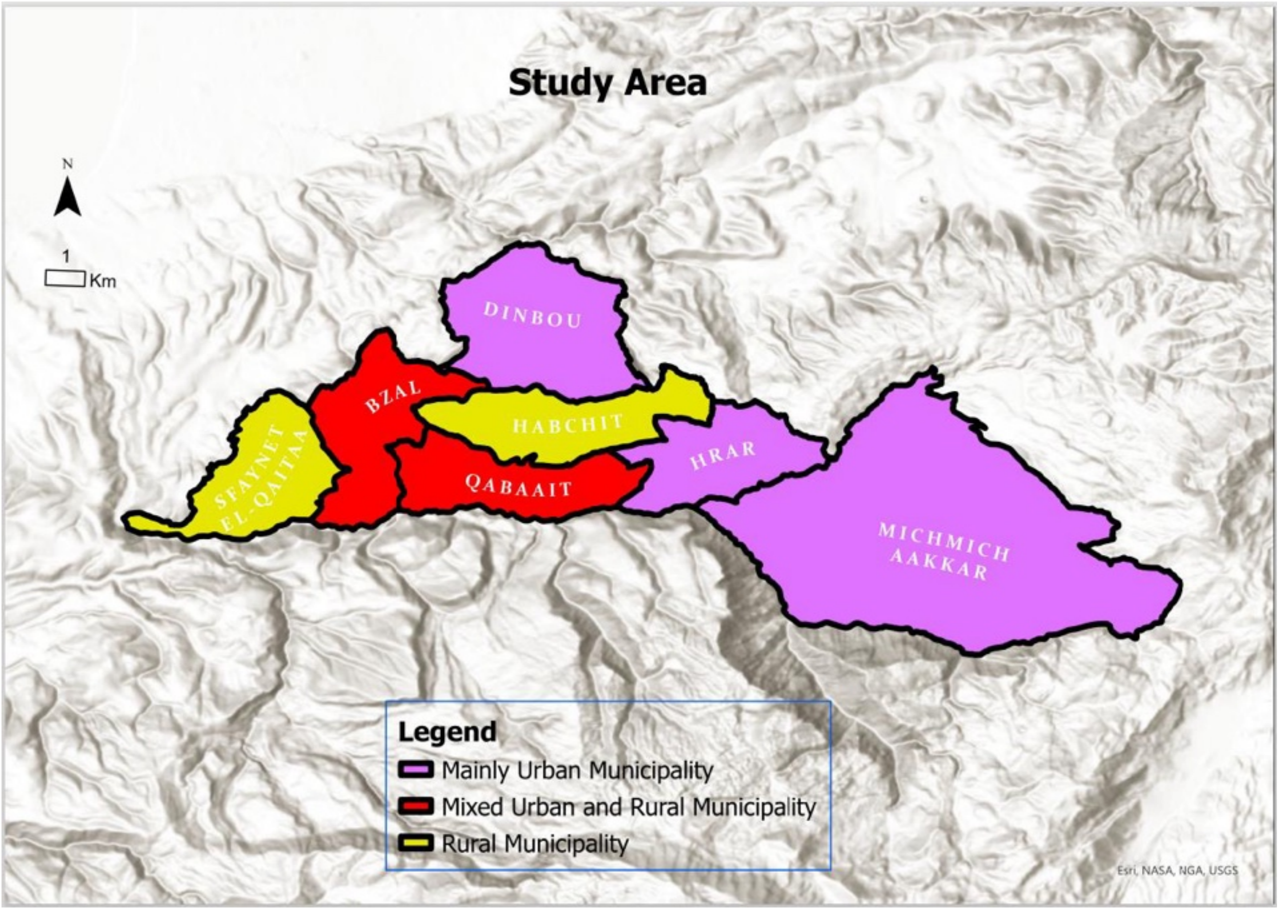

Figure 33: GIS map of Akkar Governorate showing administrative boundaries of the target municipalities (outlined in black and preliminary livelihoods classification superimposed. Mainly rural municipalities (Habchit, Sfaynet Qaitaa) are highlighted in yellow; mixed urban/rural municipalities (Bzal, Qabaait) are shown in red; and mainly urban municipalities (Michmich, Hrar, Dinbou) are shown in purple. Source: Pearl team and LRI Akkar Workshop, 2025.

Each zone represents an area within which households share similar options for obtaining food and income, access to markets, and exposure to environmental stressors. This analysis underpins the spatial prioritisation of adaptation measures (see **Section 3.4** and **Appendix A5 Akkar Workshop outputs**).

Table 4: Summary of dominant livelihood systems and principal climate-related risks in the seven municipalities of the Union of Jerd el Kayteh. Source: Walker Institute & LRI 2025; field validation 2025.

Municipality	Dominant livelihoods	Main crops / activities	Key climate-related risks
Bzal	Mixed crop-livestock	Olives, small ruminants	Water scarcity, soil erosion, wildfire
Dinbou	Rain-fed agriculture	Wheat, barley, vegetables	Drought, declining spring flows
Hrar	Irrigated horticulture, small trade	Fruit trees, vegetables	Flash floods, pest outbreaks
Michmich	Forestry, beekeeping, subsistence farming	Pine, oak, honey	Wildfire, forest pests
Qabaait	Terrace farming, seasonal labour	Olives, cereals	Landslides, loss of terraces
Sfaynet El Qaitaa	Mixed crop-livestock	Goats, wood products	Water scarcity
Habchit	Urban-agricultural mix	Market gardening, services	Water shortages, waste pollution

LRI conducted a preliminary exercise to capture finer differences in income sources and employment across the project municipalities. This exercise distinguished between predominantly urban, mixed, and predominantly rural economies, drawing on settlement patterns, land use and dominant economic activities, as well as ecological and environmental characteristics such as vegetation cover, water availability and exposure to localised hazards. This typology provided the framework for analysing how climate risks and resource stresses intersect with socio-economic conditions at community level and for structuring the subsequent consultation process (see **Appendix A4 Community consultations**).

Table 5: Preliminary livelihood sub-zones defined by LRI for the Akkar municipalities. Source: LRI (2025); Walker Institute (2025).

Provisional Livelihood Zone]	Towns / Villages	Proportion Urban	Main livelihood activities	Main Hazards
1	Habchit, Sfaynet Qaitaa	Low	Cultivation (orchards and open-field agriculture) with limited urban activities	Storms, wildfires, heatwaves, drought
2	Michmich, Hrar, Dinbou	High	Mixed livelihoods; open-field agriculture near towns	Storms, wildfires, heatwaves, drought
3	Bzal, Qabaait	Medium	Orchards and peri-urban economic activities	Storms, wildfires, heatwaves, drought, torrential rainfall, snowstorms, winter floods

A3.2 Municipal livelihood-zone profiles

Each profile below summarises the dominant livelihood systems and associated climate and environmental stresses. Local validation of this zoning was undertaken during the April 2025 workshop (see Appendix A5).

A3.2.1 Bzal

Bzal's landscape (**Figure 34**) combines low-lying farmland with upland grazing areas. Smallholder agriculture dominates, with olives and vegetables cultivated on terraced slopes. Livestock, mainly goats and sheep, provide supplementary income. Women participate actively in processing olive oil and dairy products. Rainfall variability and declining spring discharge are constraining irrigation, forcing some households to abandon marginal plots. Soil erosion and vegetation loss on steeper slopes have increased wildfire risk and reduced forage availability.

A3.2.2 Dinbou

Dinbou lies within a drier inland belt where rain-fed cereal production and vegetable cropping sustain most households (**Figure 35).** Labour migration to coastal towns is common during dry years. Farmers report shorter wet seasons and longer dry spells, leading to reduced yields and higher dependence on purchased fodder. Springs that once supplied gravity-fed irrigation now run intermittently, increasing pressure on shared wells.

A3.2.3 Hrar

Hrar has relatively fertile alluvial soils supporting irrigated fruit and vegetable production (**Figure 36).** Many families combine small trading or transport work with farming. More erratic rainfall and sudden storms have caused periodic flooding of low-lying fields, damaging crops and irrigation networks. Warmer winters have also increased pest and disease pressures on fruit trees.

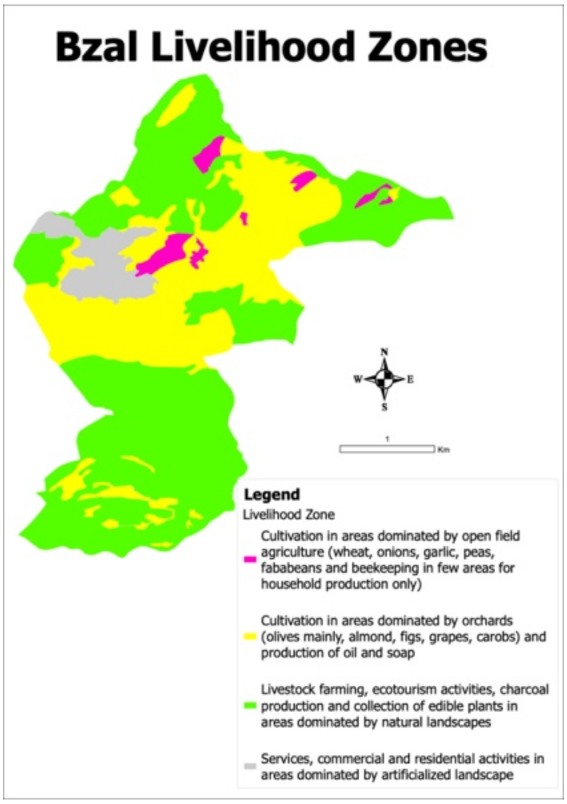

Figure 34: Livelihood zones of Bzal, Akkar Governorate. Source: Walker Institute & LRI (2025).

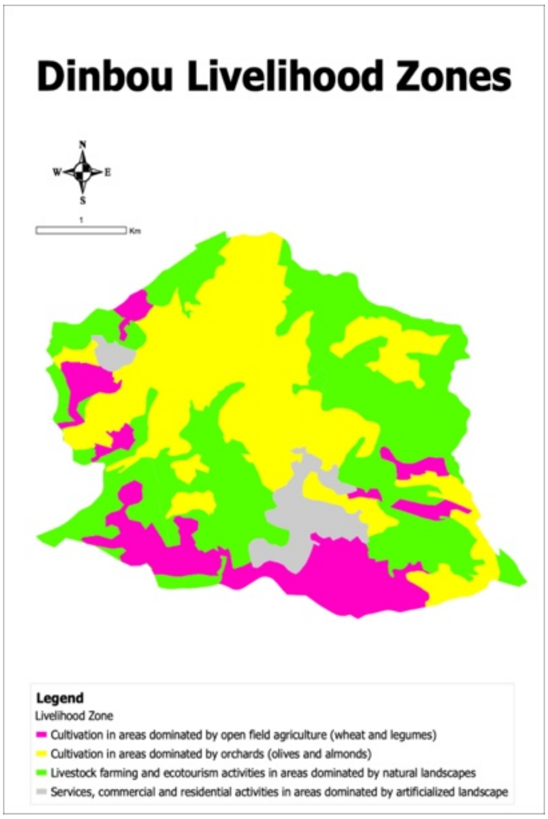

Figure 35: Livelihood zones of Dinbou, Akkar Governorate. Source: Walker Institute & LRI (2025).

Figure 36: Livelihood zones of Hrar, Akkar Governorate. Source: Walker Institute & LRI (2025).

Figure 37: Livelihood zones of Michmich, Akkar Governorate. Walker Institute & LRI (2025).

A3.2.4 Michmich

Michmich is heavily forested, with pine, oak and cypress providing timber and non-timber products **(Figure 37**). Beekeeping and small vegetable gardens supplement incomes. Forest fires have become more frequent, reducing canopy density and honey yields. Steep slopes and poor road access limit marketing opportunities, contributing to youth out-migration.

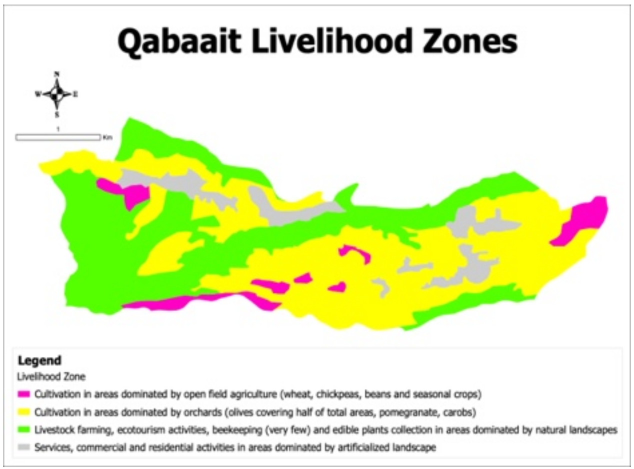

Figure 38: Livelihood zones of Qabaait, Akkar Governorate. Source: Walker Institute & LRI (2025).

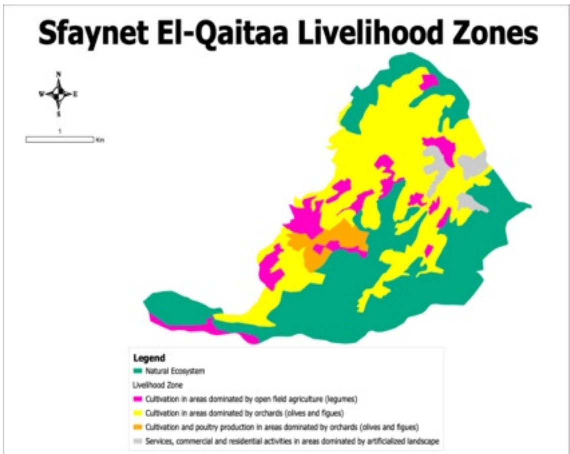

Figure 39: Livelihood zones of Sfaynet El Qaitaa, Akkar Governorate. Source: Walker Institute & LRI (2025).

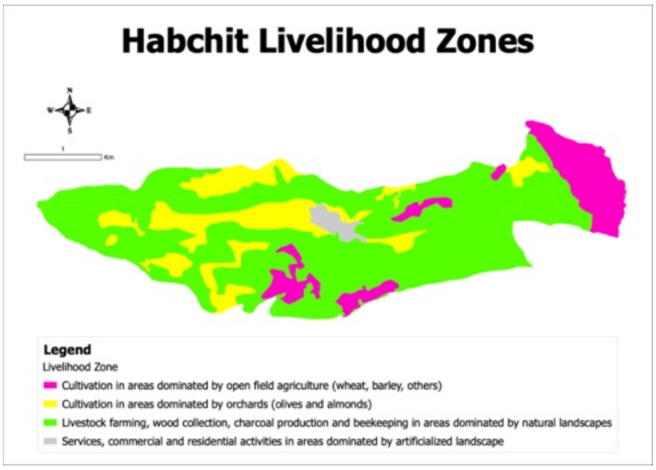

Figure 40: Livelihood zones of Habchit, Akkar Governorate.
Source: Walker Institute & LRI (2025).

A3.2.5 Qabaait

Qabaait consists of terraced agricultural lands interspersed with scrub and degraded forest (**Figure 38).** Olive cultivation and seasonal wage labour are the main income sources. Repeated droughts have accelerated terrace collapse and soil loss. Heavy downpours cause flash erosion, while limited access to credit constrains maintenance of traditional stone terraces.

A3.2.6 Sfaynet El Qaitaa

This upland municipality is characterised by rangelands and fragmented forest patches (**Figure 39).** Poultry and olives are central to livelihoods, complemented by small dairy/beef herds which are kept on farmland and occasional wage work.

A3.2.7 Habchit

Habchit combines peri-urban and agricultural zones (**Figure 40).** Many households rely on small businesses, transport and public employment alongside market gardening. Water shortages have worsened due to population growth and competition from nearby towns. Waste disposal and runoff are contaminating irrigation channels, posing risks to crop quality and human health.

A3.3 Linkages to adaptation planning

These livelihood-zone profiles provided the spatial and socio-economic baseline for identifying adaptation priorities. During the April 2025 workshop, participants used simplified versions of these maps to locate vulnerable assets and discuss potential interventions (see **Appendix A5 Akkar Workshop** outputs). The zones also supported the spatial overlay of climate storylines developed in **Appendix A2** enabling analysis of where particular sectors and communities face converging risks. This integrated mapping now guides site selection for the pilot interventions in Phase II, described in Section 6.

A4 COMMUNITY CONSULTATIONS

This appendix summarises the findings from the community consultations carried out across the seven municipalities of the Union of Jerd el Kayteh between February and April 2025. The consultations aimed to understand how households experience climate and environmental change, and to identify locally feasible adaptation measures. They built directly on the livelihood-zone profiles in **Appendix A3 Livelihood zone descriptions and maps** and provided the qualitative foundation for the participatory workshop described in **Appendix A5 Akkar Workshop** outputs.

A4.1 Consultation process

Community consultations were conducted jointly by the Lebanon Reforestation Initiative (LRI) and The Pearl (formerly the Walker Institute) with support from municipal councils. Meetings took place in each municipality and involved 20 to 35 participants representing farmers, herders, women's cooperatives, youth, local officials and civil-society organisations. Separate structured conversations were held with women and young people to ensure that less heard voices informed the process. Methods included participatory mapping, seasonal calendars and problem-tree analysis to trace how climate and livelihood pressures interact. Local facilitators guided discussions in Arabic, and anonymised notes were compiled for synthesis (LRI 2025; Walker Institute 2025).

Participants described visible shifts in the local climate: shorter wet seasons, delayed rains, longer summer heatwaves and the drying of small springs. Many said that **"*the seasons no longer follow the calendar we grew up with*."** These narratives were later compared with observational data from ERA5 and LARI stations.

These sessions were held in each of the seven municipalities, with maps and local materials used to prompt discussion.

A4.2 Emerging livelihood and environmental themes

Across all seven municipalities, discussions highlighted four recurring themes raised persistently through the consultations:

1. **Water scarcity and competition:** Communities reported declining spring flows, reduced snowmelt and contamination of shallow wells. In several upland villages, competition for irrigation water has caused disputes between herders and farmers, resolved informally through municipal mediation.
2. **Soil and vegetation degradation**: Residents linked increased erosion and loss of vegetation to more intense rainfall events and frequent fires. Farmers noted that terraces "***collapse more often after heavy rain***" and that re-planting trees has become harder because of grazing pressure.
3. **Changing agricultural calendars**: The timing of planting and harvesting has become unpredictable. Participants explained that traditional indicators, such as the appearance of certain flowers or insect cycles, no longer align with rainfall onset.
4. **Livelihood diversification and migration**: Reduced farm income has driven many households to seek wage labour in Tripoli or abroad. Women's groups described taking on new responsibilities in processing, marketing and small-scale trade.

A4.3 Gender, inclusion and conflict sensitivity

The consultation process emphasised inclusive participation. Female facilitators from LRI led the women's focus groups, ensuring open discussion of household water management, energy use and food production. Youth participants, many engaged in seasonal labour or study, highlighted barriers to land access and finance for small enterprises. Participants in mixed groups agreed that water scarcity and forest fires are shared concerns, transcending political or sectarian boundaries. One municipal official observed that "***when water runs short, everyone suffers, so we learn to cooperate*.**"

A4.4 Locally proposed adaptation measures

Each consultation concluded with identifying feasible adaptation actions for their municipality. Over forty suggestions were recorded and later screened against technical and nature-based-solutions criteria (see **Appendix A6 Nature-based Solutions (NbS)** - Screening of interventions). The most frequently proposed measures included rehabilitation of traditional cisterns and small reservoirs, soil and slope protection through re-vegetation, promotion of drip irrigation and improved water storage, establishment of local nurseries for native trees, community fire-prevention awareness campaigns, and capacity-building for women and youth in value-addition and cooperative management.

Examples of these proposed measures are summarised in **Table 6** which also shows their indicative feasibility ratings.

Table 6: Examples of community-identified adaptation measures by sector and indicative feasibility. Source: LRI (2025); Walker Institute (2025).

Sector	Example measures	Indicative feasibility
Water management	Cistern rehabilitation; rooftop rainwater harvesting; drip-irrigation training	High
Agriculture	Terrace repair; drought-tolerant varieties; community seed banks	Moderate-High
Forestry	Firebreak maintenance; reforestation with native species	Moderate
Livelihood diversification	Women's cooperatives; apiculture and small-enterprise training	Moderate

These results were subsequently consolidated and ranked by partners (LRI with support from The Pearl and UNEP)

A4.5 Summary insights

The consultations revealed strong local awareness of climate risks and a willingness to collaborate on practical solutions. Participants consistently emphasised the need for coordinated water management and technical support, rather than new infrastructure alone. They also recognised that building resilience depends on strengthening livelihoods and social cohesion as much as on environmental measures.

These insights informed the design of the April 2025 workshop and continue to shape the implementation planning under Phase II. Detailed artefacts from the workshop, including identification of feasible adaptation measures, are provided in **Appendix A5 Akkar Workshop** outputs.

A5 Akkar Workshop outputs

This appendix presents the main outputs from the participatory workshop held in Akkar, Lebanon, on 4 to 5 April 2025.

The event brought together representatives of the seven municipalities in the Union of Jerd el Kayteh, alongside technical staff from the Lebanon Reforestation Initiative (LRI), The Pearl (formerly the Walker Institute) and the Royal Scientific Society (RSS).

The workshop synthesised analytical results and community insights gathered during earlier consultations (see **Appendix A4 Community consultations**) to co-develop a shared portfolio of feasible adaptation options.

A5.1 Objectives and structure

The workshop had three objectives:

- **1**: To validate the climate-risk and livelihood-zone analyses (Appendix A2 and A3)
- **2**: To identify feasible adaptation interventions using nature-based-solutions (NbS) criteria; and
- **3**: To agree on next steps for planning and implementation under Phase II.

Participants were grouped by municipality and sector, alternating between plenary and breakout sessions. Visual materials prepared by The Pearl, including ERA5 and EarthMap visualisations, maps, and photographs of degraded area, were used to prompt discussion. Facilitators employed participatory mapping exercises. **Table 7** summarises the sequence and objectives of the workshop sessions.

Table 7: Structure of participatory workshop sessions. Source: LRI (2025); Pearl team records

Session	Focus / Objectives	Key Methods	Main Outputs
1	Validation of climate and livelihood evidence	ERA5 & EarthMap visualisation, map verification	Locally validated risk and livelihood maps
2	Identification of adaptation options	Participatory mapping, matrix scoring	Adaptation measures by sector
3	Synthesis and next steps	Plenary synthesis, consensus discussion	Consolidated adaptation portfolio for Phase II

A5.2 Session 1: Validating evidence and risks

The first session revisited the climate and livelihood evidence presented in Appendices A2 and A3. ERA5 visualisations and the preliminary livelihood-zone maps were displayed to stimulate discussion on observed and expected changes. Participants confirmed that the maps captured local realities and added fine-scale details such as spring locations, forest edges and areas of frequent fire (see the livelihoods zone maps presented in **Appendix A3.2.1**).

Recurring observations included:

- Springs drying earlier and at higher elevation each summer.
- Forest-fire frequency increasing over the past decade.
- Cropping calendars becoming unpredictable.

These insights confirmed and localised the quantitative evidence summarised in Section 2 of the main report.

A5.3 Session 2: Identifying feasible adaptation measures and subsequent initial ranking by partners (LRI with support from The Pearl and UNEP)

During the second session, each group proposed sector specific adaptation options (see **Table 8).** Facilitators ensured that both men and women contributed.

Groups discussed how certain measures could serve multiple purposes - for example, terrace repair reduces soil erosion and creates short-term employment.

Table 8: Community-prioritised adaptation measures by sector along with subsequent initial [*or delete this column of the table]* feasibility ranking. Source: LRI (2025); Walker Institute (2025).

Sector	Priority measures	Average feasibility rating

Water management	Rehabilitation of cisterns; small check-dams; drip-irrigation systems; watershed re-vegetation	4.7 / 5 (High)
Agriculture	Terrace stabilisation; drought-tolerant crops; organic fertiliser trials; on-farm training	4.3 / 5 (High)
Forestry and rangelands	Firebreak maintenance; selective planting; assisted natural regeneration	4.1 / 5 (Moderate-High)
Livelihood diversification	Apiculture; women-led cooperatives; eco-tourism services	3.9 / 5 (Moderate)

A5.4 Session 3: Synthesis and next steps

In the final session, groups presented their set of feasible interventions for each municipality (see **Table 8**). Participants also agreed on cross-municipal coordination mechanisms and on establishing a shared learning forum to monitor implementation progress. Figure 4 presents the composite ranking by overall priority from subsequent discussions between partners (LRI with support from The Pearl and UNEP).

These results formed the practical basis for the Phase II implementation plan described in **Section 6 Next steps and implementation plan** of the main report.

A5.5 Key insights from the workshop

Discussions throughout the workshop underscored several lessons for adaptation planning in fragile contexts:

- **Local knowledge and scientific evidence**: Combining quantitative analysis with lived experience deepened understanding and trust.
- **Inter-municipal collaboration**: Neighbours shared similar risks and recognised benefits from joint watershed actions.
- **Inclusive facilitation**: Participation of women, youth and municipal leaders increased acceptance of prioritised actions.
- **Pragmatism under constraint**: Communities valued simple, low-cost measures deliverable with existing capacities.

These lessons are reflected in Section 5 of the main report and inform the ongoing design of Phase II.

A6 NATURE-BASED SOLUTIONS (NBS) - SCREENING OF INTERVENTIONS

A6.1 Purpose and approach

Following the participatory workshop in April 2025 (**Appendix A5**), a set of more than forty community-identified adaptation measures was screened using simplified UNEP (2024) NbS criteria adapted from the UNEP *Guidelines for Nature-based Solutions for Climate and Disaster Resilience* and cross-checked with IUCN (2020) Global Standard for NbS. The screening assessed the extent to which proposed actions contribute simultaneously to ecological integrity, social inclusion and economic resilience.

The simplified NbS screening tool applied four evaluation dimensions adapted from UNEP (2024). Each dimension contained sub-criteria as outlined in **Table 10**.

Table 9: Prioritisation criteria and sub-criteria for adaptation measures. Source: LRI (2025); Walker Institute (2025); UNEP (2024).

Criterion	Sub-Criteria	Description	Scoring Guidance (1-5)
1. Feasibility	Technical feasibility; resource availability; maintenance requirements	Can the measure be implemented with available materials, knowledge and time? Is it cost-effective and locally maintainable?	1 = Not feasible; 5 = Easily implementable
2. Impact and sustainability	Environmental benefit; livelihood improvement; long-term durability	Does the action protect, restore or sustainably manage natural ecosystems? Does it strengthen livelihoods, reduce vulnerability and promote equity? Does it sustain benefits beyond the project period?	1 = Short-term/uncertain; 5 = Long-term positive impact
3. Inclusiveness and gender sensitivity	Participation of women and youth; equitable benefit sharing	Does it increase participation and reduce inequality?	1 = Limited inclusion; 5 = Strongly inclusive
4. Conflict sensitivity and cooperation potential	Potential to reduce competition and promote joint action	Does it strengthen cooperation or mitigate local tensions and avoid harm?	1 = May increase tension; 5 = Promotes collaboration

Each proposed measure was scored from 1 (low) to 5 (high) under each dimension through group discussions between LRI, and The Pearl technical team.

A6.2 Summary of screening results

Table 11 summarises composite scores for the ten highest-ranked measures. These options were retained for detailed feasibility assessment in the Phase II implementation plan (see Section 6 of the main report).

Table 10: Summary of NbS screening scores for priority adaptation measures. Source: LRI (2025); Walker Institute (2025); UNEP (2024).

No.	Measure	Ecosystem integrity	Societal benefits	Economic feasibility	Governance / conflict sensitivity	Composite (/ 5)
1	Catchment re-vegetation and slope stabilisation	4.8	4.6	4.3	4.7	4.6
2	Rehabilitation of traditional cisterns and ponds	4.5	4.8	4.5	4.6	4.6

3	Terrace repair and vegetative barriers	4.2	4.4	4.1	4.5	4.3
4	Firebreak maintenance and community awareness	4.0	4.3	4.2	4.6	4.3
5	Drip-irrigation training and demonstration plots	3.9	4.5	4.7	4.1	4.3
6	Beekeeping and forest pollination corridors	4.3	4.2	4.0	4.2	4.2
7	Nursery production of native trees	4.6	4.1	3.9	4.0	4.2
8	Contour ploughing and soil-moisture retention	4.1	4.3	4.0	4.2	4.2
9	Apiculture and women's cooperatives	3.8	4.5	4.0	4.1	4.1
10	Small-scale eco-tourism and forest trails	3.9	4.2	3.8	4.0	4.0

Scores reflect collective judgement rather than statistical precision; they indicate relative perceived strength across the four dimensions.

A6.3 Key observations from screening

Several trends emerged across the scoring exercise:

1. **High synergy between ecosystem and social benefits**. Measures protecting forest and water resources were also those most valued by communities for income and security.
2. **Gender and inclusion impacts**. Activities such as apiculture and nursery management scored strongly under societal benefits due to women's participation and low entry costs.
3. **Governance and conflict sensitivity**. Water-harvesting and grazing-management actions achieved high ratings where inter-municipal cooperation was already established.
4. **Economic feasibility**. Simple, low-maintenance measures (e.g., terrace repair) ranked higher than capital-intensive options, aligning with community preferences noted in **Appendix A5 Akkar Workshop outputs.**

These results show that ecosystem-based measures deliver the strongest co-benefits when combined with livelihood diversification and inclusive governance.

A6.4 Limitations and next steps

The simplified screening focused on rapid field-level prioritisation within limited project timeframes. Quantitative assessment of carbon, biodiversity and economic outcomes will require more detailed data collection during Phase II. Nevertheless, the participatory scoring provided a practical and transparent framework for decision-making under uncertainty.

Findings from this appendix feed directly into Section 6 (Next Steps) of the main report and the Phase II implementation plan developed with LRI.

A6.5 Lessons for mainstreaming NbS

The Akkar screening exercise demonstrated that simple, inclusive and locally led interventions can achieve high alignment with UNEP's NbS principles. Strengthening practice in future projects will depend on integrating joint ecological and social indicators, such as vegetation cover, spring discharge and women's income, into monitoring and evaluation frameworks, so that progress can be measured holistically.

Low-cost, co-operative interventions that build on existing institutions are most likely to deliver sustained benefits, provided they are supported by gender-responsive training and clear communication channels between communities and implementing partners. Applying this same rapid, participatory screening model to other UNEP regional initiatives would ensure consistency across projects and help embed Nature-based Solutions as a core pillar of adaptation planning under the Climate, Environment and Security Partnership.

A7 SURVEY INSTRUMENTS AND COMMUNITY CONSULTATION METHODS

A7.1 Purpose

This appendix presents the tools used to collect primary data for the Akkar project, including those applied during community consultations and the April 2025 participatory workshop. They were designed jointly by the Lebanon Reforestation Initiative (LRI) and The Pearl (formerly the Walker Institute), with input from UNEP's adaptation and social-science specialists. Each tool was tested in one pilot municipality and then applied across all seven municipalities of the Union of Jerd el Kayteh.

These instruments ensured that local experience, gender perspectives and institutional insights were systematically captured and that all information was collected in a consistent and ethical manner.

They complement the analytical methods described in Section 3 of the main report.

A7.2 Overview of instruments and consultation process

Community consultations in Akkar combined three complementary methods:

1. **Key-Informant Interviews (KIIs)** - one-to-one or small group discussions with municipal officials, technical officers, water-user associations, agricultural cooperatives and NGOs to gather institutional perspectives on e.g., local governance, infrastructure status, and environmental challenges.
2. **Focus-Group Discussions (FGDs)** - small, structured sessions within each municipality. (8-12 participants) with farmer groups, women's associations, and youth representatives to capture community perceptions of climate change, lived experiences, coping strategies, and priorities for adaptation.
3. **Participatory Workshop Sessions** - plenary and breakout exercises held in April 2025 to validate findings and co-develop adaptation measures using structured participatory tools (problem-tree analysis, mapping).

Together, these activities formed the community consultation process through which scientific and local knowledge were integrated for adaptation planning. All instruments were reviewed for clarity and cultural and linguistic relevance, then applied by LRI facilitators with technical support from The Pearl team.

The Community Consultation Guide used by LRI operationalised these methods, outlining the sequencing of FGDs, participatory mapping and ranking within each municipal consultation session.

A7.3 Key-Informant Interview Guide

Objective: To capture institutional perspectives on climate impacts, resource management and coordination mechanisms.

Indicative questions:

- What are the main climate-related challenges currently affecting your municipality or sector?
- How have rainfall, temperature and water availability changed over the past decade?
- Which groups or sectors are most vulnerable to these changes?
- What adaptation or risk-reduction actions are currently being implemented?
- What coordination exists between municipalities, ministries and NGOs on water, forestry or agricultural management?
- What are the principal constraints to implementing new measures?

Each interview lasted 45-60 minutes, and responses were anonymised and coded under thematic categories (water, agriculture, forest, livelihoods, governance/conflict sensitivity).

A7.4 Focus-Group Discussion Guide

Objective: To explore community perceptions of change, local coping strategies and collective priorities through structured group sessions forming the core of the community consultation process.

Each FGD comprised 8-12 participants and complemented household consultations by enabling collective reflection on shared challenges and opportunities (see **Table 12)**. Separate groups were used for women and youth.

Session outline:

1. Opening discussion on recent climatic trends and their impacts on crops, livestock and water;
2. Group ranking of the most severe livelihood stresses;
3. Mapping exercise to locate areas affected by drought, erosion, or fire;
4. Identification of coping mechanisms and preferred adaptation options;
5. Closing reflection on barriers to action and support needed from institutions.

Facilitators used cards and simple icons to ensure inclusion of participants with limited literacy. Consent was obtained before all discussions.

Table 11: Outline of focus group discussion guide. Source: LRI (2025); Walker Institute (2025).

Session component	Objective	Example prompts
1. Introduction and mapping	Identify key livelihood resources and areas affected by climate stress	"Show on the map where water shortages occur most frequently."
2. Seasonal calendar	Document timing of farming, migration and rainfall events	"When does the rainy season usually begin and end now?"
3. Problem-tree analysis	Identify causes and effects of main livelihood problems	"What are the root causes of declining crop yields?"
4. Solutions	Generate potential adaptation measures	"Which actions are most realistic for your community?"
5. Gender and conflict sensitivity	Explore differences in experiences and decision-making	"Who decides how water is used when it becomes scarce?"

Group discussions lasted 60-90 minutes and typically involved 8-12 participants. Each session concluded with a brief reflection on cooperation between households and municipalities.

A7.5 Community Consultation Questionnaire

The community consultation questionnaire captured perceptions of climatic change, impacts on livelihoods and local adaptation responses. It combined open and closed questions to enable comparison across sites while retaining qualitative richness. An abbreviated version is shown below in **Table 13.**

Table 12: Key sections of the community consultation questionnaire. Source: LRI (2025); Walker Institute (2025).

Section	Question themes	Example questions
A. Household profile	Demographics, main livelihood activities, land ownership	"What are your household's main sources of income?"
B. Climate perception	Observed changes in rainfall, temperature and seasons	"Have rainfall patterns changed in the last ten years?"
C. Livelihood impacts	Effects of climate change on crops, water and forests	"How have these changes affected your main livelihood?"
D. Coping strategies	Adaptation measures already practised	"What actions have you taken to reduce climate risks?"
E. Priority needs	Support required for adaptation	"What would most help your community adapt to these changes?"
F. Social inclusion	Gender, youth and conflict-sensitivity aspects	"Who in the community benefits least from current support?"

All interviews were conducted in Arabic by trained local facilitators.

Responses were recorded on paper forms and later digitised using KoboToolbox for coding and synthesis.

A7.6 Participatory Workshop Templates

The participatory workshop (Appendix A5) employed standard templates for mapping and NbS screening.

Each group received printed maps of their municipality (1:25,000 scale) and markers.

Templates included:

- **Hazard-impact matrix** linking climate hazards to affected sectors and population groups;
- **Feasibility-impact ranking table** for proposed interventions;
- **Gender and inclusion checklist** to track participation and representation across sessions.

At the end of the April 2025 workshop (see **Appendix A5 Akkar Workshop outputs**), participants completed a short evaluation form to capture feedback on process quality, relevance and learning outcomes.

The evaluation included five questions rated on a 1-5 scale:

1. Clarity of information presented.
2. Usefulness of group discussions.
3. Inclusiveness and participation.
4. Practical relevance of identified measures.
5. Overall satisfaction with the workshop.

Open-ended comments were also invited. Responses were summarised to inform improvements for future workshops.

A7.7 Data management and ethical consideration

All data were collected under informed consent obtained verbally at the start of each session, following University of Reading ethics guidelines and the LRI and UNEP data handling policies. Names of individuals were not recorded; responses were coded by municipality, gender and stakeholder group. Handwritten notes were transcribed and stored securely. Digital datasets are held by The Pearl and LRI and available to UNEP West Asia on request.

A7.8 Link to analysis

The data collected through these instruments formed the qualitative foundation for Sections 2.2 and 3.2 of the main report, enabling triangulation between community perceptions, quantitative climate trends and the spatial livelihood-zone analysis (Appendix A3).

They also inform the design of the monitoring, evaluation and learning (MEL) framework for Phase II.

A8 POLITICAL AND SECURITY ASSESSMENT

A8.1 Purpose

This appendix summarises findings from the rapid political and security context assessment developed together by The Pearl and the Lebanon Reforestation Initiative (LRI)and wider team in March-April 2025. The assessment aimed to identify governance, institutional and social-cohesion factors affecting implementation of climate-resilience and nature-based-solution (NbS) measures in Akkar Governorate.

It was based on a review of policy and security documents, semi-structured interviews with municipal officials and community representatives, and triangulation with the April 2025 participatory workshop outcomes.

A8.2 Overview of governance structures

Akkar's municipalities operate under Lebanon's decentralised municipal law, with limited fiscal autonomy and dependence on transfers from the central government. The Union of Jerd el Kayteh provides a coordination platform for joint service delivery and natural-resource management. Local governance is shaped by municipal councils, mukhtars and community associations. Although administrative boundaries are clear, functional responsibilities for forestry, agriculture and water often overlap between ministries and municipalities, complicating project execution.

At the district level, coordination between municipal unions and the Governor's Office has improved since 2021 through donor-supported initiatives on local development and solid-waste management. However, frequent changes in national government and fiscal constraints have reduced continuity of policy support for environmental programmes.

A8.3 Security and social stability

While Akkar has remained largely stable, communities face cumulative stress from poverty, limited services and regional spill-overs. Competition over scarce resources, particularly water and grazing land, has occasionally heightened local tensions (see **Table 14).** Municipal mediation and long-standing social networks have so far prevented escalation. The presence of displaced populations places additional pressure on infrastructure but also contributes labour and market demand.

Local security forces coordinate with municipalities on wildfire prevention, forest-access regulation and enforcement of water-use restrictions. Inter-municipal collaboration in these areas has strengthened trust between neighbouring communities.

Table 13: Main factors influencing stability and cooperation in Akkar. Source: LRI (2025); Walker Institute (2025).

Factor	Effect on local stability	Implications for adaptation planning
Water scarcity and uneven access	Periodic disputes among users	Prioritise equitable allocation and joint maintenance of sources
Forest fires and illegal logging	Environmental degradation and economic loss	Strengthen community fire-management committees
Unemployment and youth migration	Loss of skilled labour	Integrate livelihood diversification into NbS planning
Presence of displaced populations	Increased demand for services	Include host-refugee cooperation mechanisms
Weak fiscal transfers	Limited municipal investment capacity	Seek co-financing and technical support
Strong local mediation networks	Conflict prevention capacity	Build on existing social-cohesion structures

A8.4 Institutional and conflict-sensitivity implications

The analysis confirmed that climate-resilience interventions must account for the political economy of resource access. Actions that alter water distribution or land-use rights can inadvertently generate tension if not managed transparently, whereas joint management initiatives provide platforms for cooperation.

Embedding peace and security expertise alongside technical specialists proved valuable in identifying these sensitivities early.

Integrating the assessment with adaptation planning enabled project partners to:

- locate interventions in socially neutral or shared spaces;
- design participatory maintenance mechanisms to prevent contestation; and
- strengthen relationships between municipal councils and community groups.

These findings have been mainstreamed into the feasibility screening and prioritisation process (see **Appendix A9 Prioritisation criteria matrix**).

A8.5 Key lessons

The assessment highlighted several overarching factors for designing and implementing adaptation measures in politically and socially complex settings.

1. Conflict sensitivity is a prerequisite for sustainability. Anticipating potential distributional effects helps avoid reinforcing inequalities.
2. Municipal mediation capacity is a strength to build upon. Local dispute-resolution practices complement formal governance.
3. Peace and security analysis enhances technical planning. Interdisciplinary collaboration improves both design and community acceptance.

These lessons inform the operational guidance provided in **Section** Error! Reference source not found. of the m ain report and will guide implementation in Phase II.

A9 PRIORITISATION CRITERIA MATRIX

A9.1 Purpose and overview

This appendix presents the criteria matrix used to evaluate and prioritise community-identified adaptation measures during the Akkar participatory process. The matrix operationalises the ICECCAP principle of transparent, evidence-based decision-making, linking feasibility and impact considerations with inclusion and conflict sensitivity. It complements the summary of results in Appendix A6 (NbS Screening) and underpins the composite ranking discussed in Section 3.4 of the main report.

The tool was co-designed by The Pearl and LRI, adapted from UNEP (2024) and World Bank (2023) community-resilience frameworks.

A9.2 Structure of the matrix and scoring

Each adaptation option was assessed against the following seven criteria shown in **Table 15**.

Scoring was based on group consensus following discussion between Partners (LRI with support from The Pearl and UNEP) and verification against technical evidence.

The prioritisation process applied four main criteria, each composed of several sub-criteria. Groups scored each proposed measure collectively, using facilitation cards and plenary discussion to reach consensus. Scores were assigned on a 1-5 scale, where 1 = low and 5 = high. Average scores across groups produced the composite ratings presented in **Appendix A5**.

Table 14: Participatory prioritisation criteria and definitions used in the Akkar adaptation measure scoring. Source: LRI (2025), Walker Institute (2025); UNEP (2024).

Criterion	Definition / guiding question	Scoring scale (1-5)
1. Technical feasibility	Is the measure technically achievable with available skills and resources?	1 = Low feasibility; 5 = High feasibility
2. Cost-effectiveness	Can the measure deliver tangible benefits with reasonable investment and maintenance costs?	1 = High cost, low return; 5 = Low cost, high return
3. Environmental impact	Does it protect, restore, or sustainably manage ecosystems?	1 = Negative impact; 5 = Strong positive impact
4. Livelihood benefit	Does it improve or diversify household income and food security?	1 = Minimal impact; 5 = Substantial improvement
5. Gender and inclusion	Does it expand participation and benefits for women, youth, and marginalised groups?	1 = Exclusionary; 5 = Highly inclusive
6. Conflict sensitivity	Does it reduce competition over resources and strengthen cooperation?	1 = Potentially divisive; 5 = Conflict-preventive
7. Sustainability and local ownership	Is the measure likely to continue beyond project support, with local institutions engaged?	1 = Low likelihood; 5 = High likelihood

Each measure received a weighted average score calculated as:

$$Composite\ Score = \frac{\sum(S_i \times W_i)}{\sum W_i}$$

where S = individual sub-criterion score and W = agreed weighting (equal weights applied in this phase).

Each score was justified through group discussion. Facilitators recorded the rationale in workshop notes to preserve transparency and enable later verification.

A9.3 Application in the Akkar Workshop

The matrix was applied to the consolidated list of forty community-proposed measures (see Appendix A5).

Scores from the seven criteria were averaged to produce a composite ranking.

Measures achieving average scores above 4 were classified as high priority and advanced to the NbS screening step in Appendix A6.

Examples include cistern rehabilitation, catchment re-vegetation, terrace repair and drip-irrigation training.

A9.4 Illustrative results

Table 16 presents a sample of the consolidated scoring results showing ten representative measures and their average scores across all criteria. The full dataset is archived with LRI and The Pearl.

Table 15: Extract from prioritisation results (average 1-5 scale)

Measure	Tech. Feas.	Cost Eff.	Env. Impact	Livelihood Benefit	Gender Incl.	Conflict Sens.	Sustain.	Composite
Rehabilitation of cisterns and ponds	4.7	4.5	4.8	4.6	4.3	4.5	4.6	4.6
Catchment re-vegetation and slope stabilisation	4.5	4.2	4.9	4.4	4.2	4.6	4.5	4.5
Terrace repair and vegetative barriers	4.3	4.1	4.5	4.2	4.1	4.4	4.2	4.3
Drip-irrigation training and demonstration plots	4.1	4.3	4.1	4.3	4.2	4.0	4.1	4.2
Firebreak maintenance and community awareness	4.0	4.1	4.3	4.0	4.0	4.5	4.2	4.2
Beekeeping and forest pollination corridors	4.2	4.0	4.2	4.3	4.5	4.1	4.0	4.2
Apiculture and women's cooperatives	3.9	4.1	4.0	4.2	4.7	4.1	4.0	4.1
Contour ploughing and soil-moisture retention	4.0	4.1	4.3	4.1	4.0	4.2	4.1	4.1
Nursery production of native trees	4.1	4.0	4.3	4.0	4.1	4.0	4.1	4.1
Small-scale eco-tourism and forest trails	3.9	3.8	4.0	4.0	4.0	4.0	3.9	4.0

The aggregated results formed the basis for the NbS screening in Appendix A6.

As shown in **Table 16**, water and land-management measures received the highest average scores across all municipalities.

A9.5 Interpretation and use

The prioritisation results served three main purposes:

1. **Decision support**: Provided an objective reference for communities and technical teams to agree on final intervention packages.
2. **Transparency**: Recorded the rationale behind each decision, ensuring accountability and replicability.
3. **Learning**: Identified where criteria weightings could be refined in future rounds, for example to emphasise gender inclusion or long-term sustainability.

High-scoring measures were validated by all seven municipalities and integrated into the Phase II implementation plan (see Section 6 of the main report).

The prioritisation process revealed that:

- The matrix offered a structured yet rapid assessment approach.
- Technical feasibility was closely linked to community familiarity and availability of local materials.
- Measures offering both livelihood and ecological benefits scored consistently high.
- Inclusion and conflict-sensitivity criteria provided a practical way to integrate social dimensions into what is often a technical ranking exercise.

A9.6 Summary

The Akkar prioritisation matrix provides a transparent bridge between participatory preferences and structured decision-making. The composite rankings produced through this matrix guided the selection of pilot interventions for Phase II implementation. During Phase II, LRI and The Pearl, subject to funding, will refine weightings based on detailed feasibility studies and cost-benefit analysis to ensure alignment with national adaptation and NbS strategies.

By combining scientific evidence with inclusion and conflict-sensitivity parameters, it strengthens ownership of the adaptation plan and offers a transferable model for UNEP adaptation planning in fragile contexts.

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