Watershed Reforestation: Opportunities for Reducing Stormwater Runoff

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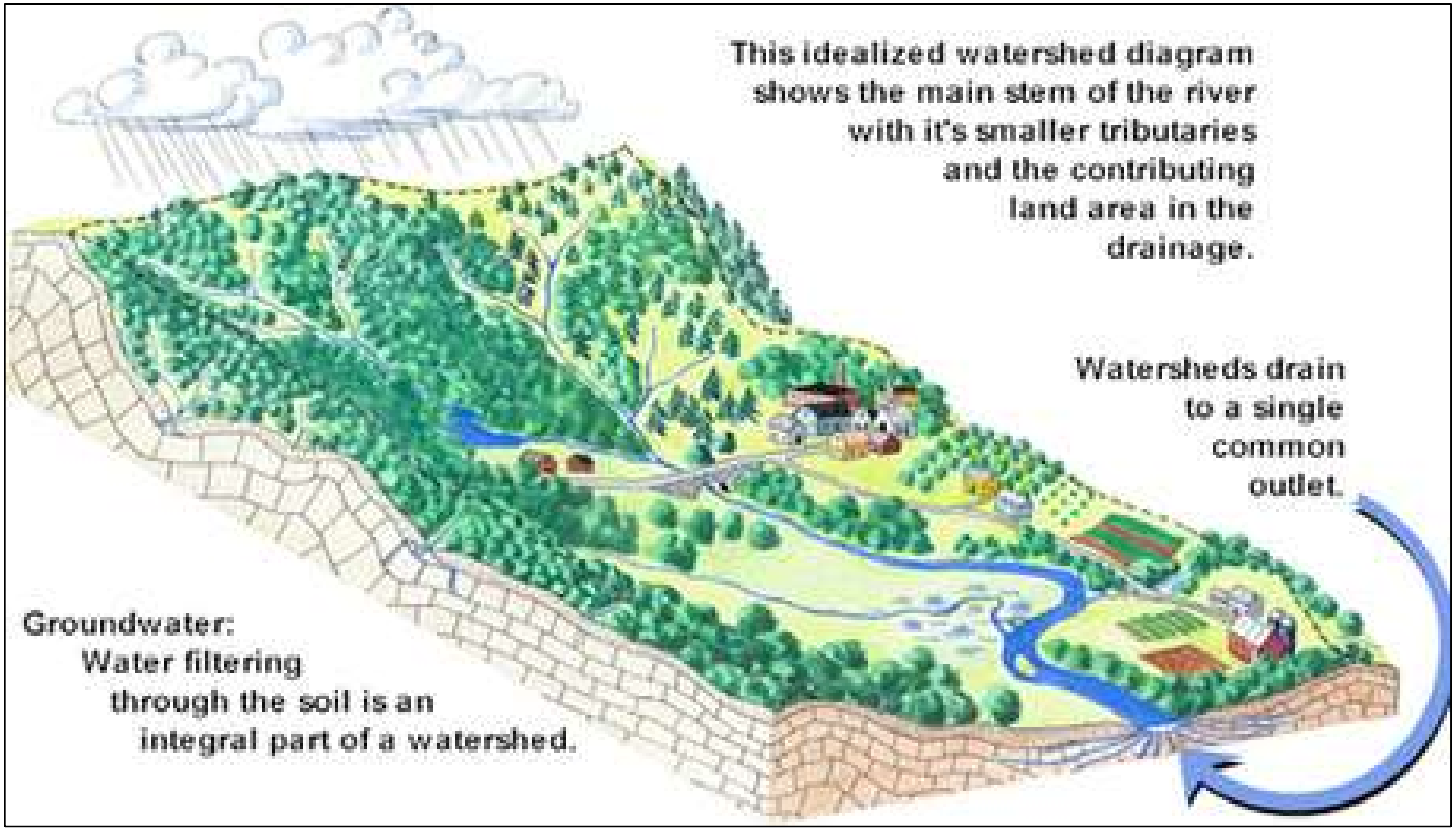
Understanding Watersheds

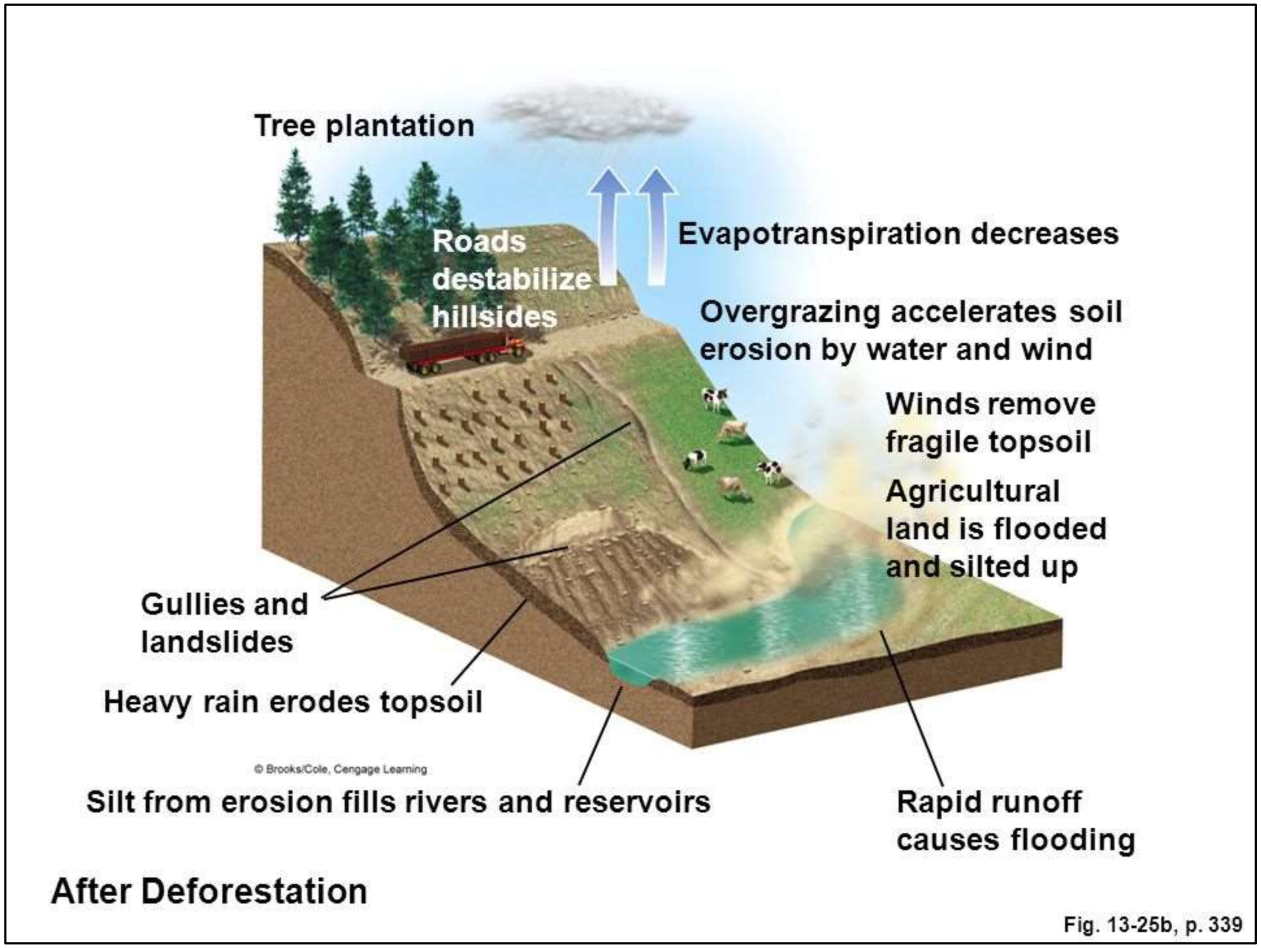
- **Definition and Components of a Watershed**: A land area that channels rainfall and snowmelt to creeks, streams, and rivers, eventually leading to outflow points.
- **Role of Vegetation in Watersheds:** Vegetation helps in water infiltration, reducing runoff, and stabilizing soil.



Source: columbiaccd

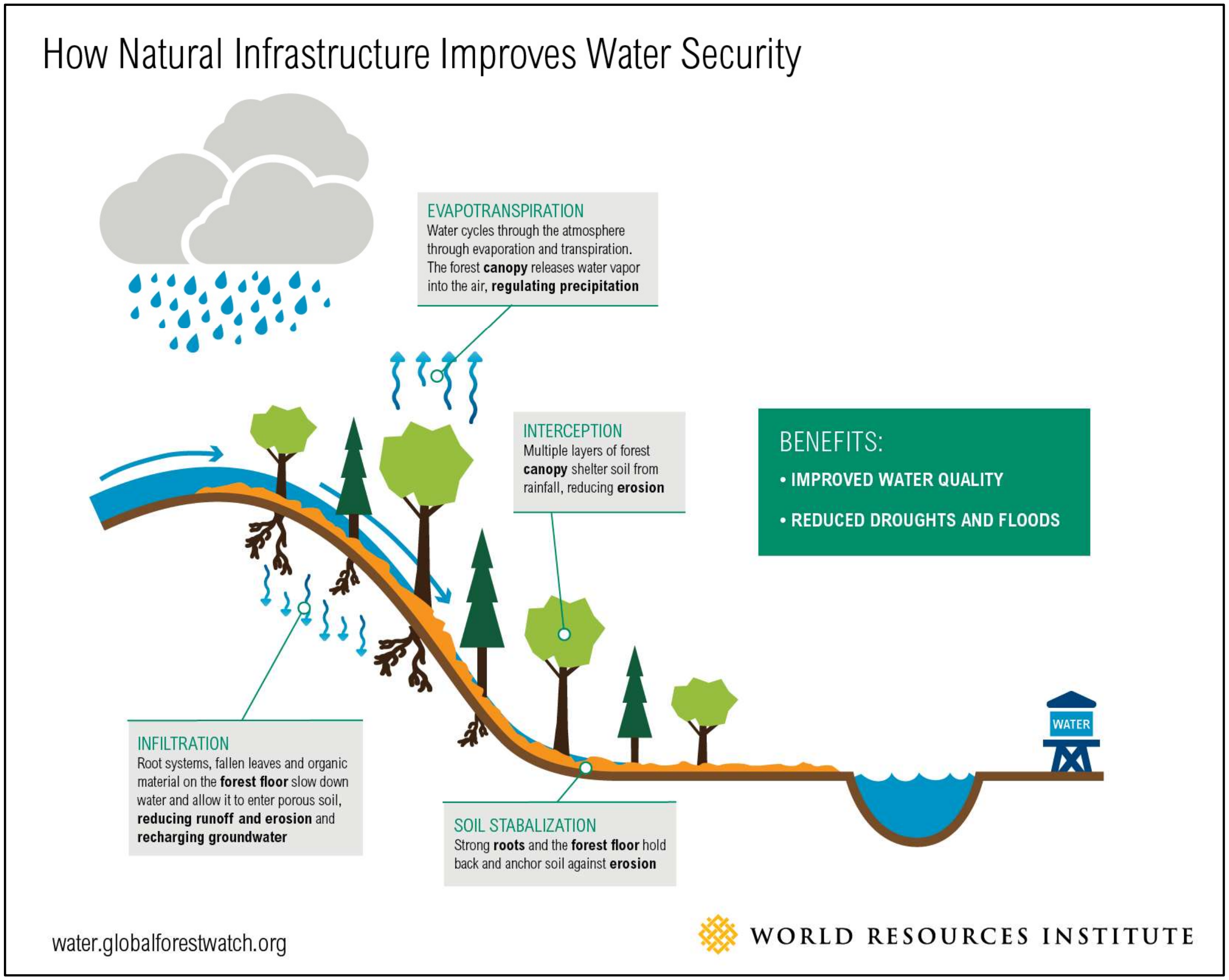
Impact of Deforestation on Watersheds

- **Increased Stormwater Runoff**: Leads to flooding and decreased groundwater recharge.
- **Soil Erosion**: Loss of topsoil, reduced soil fertility.
- **Water Quality Degradation**: Increased sediment and pollutant load in water bodies.



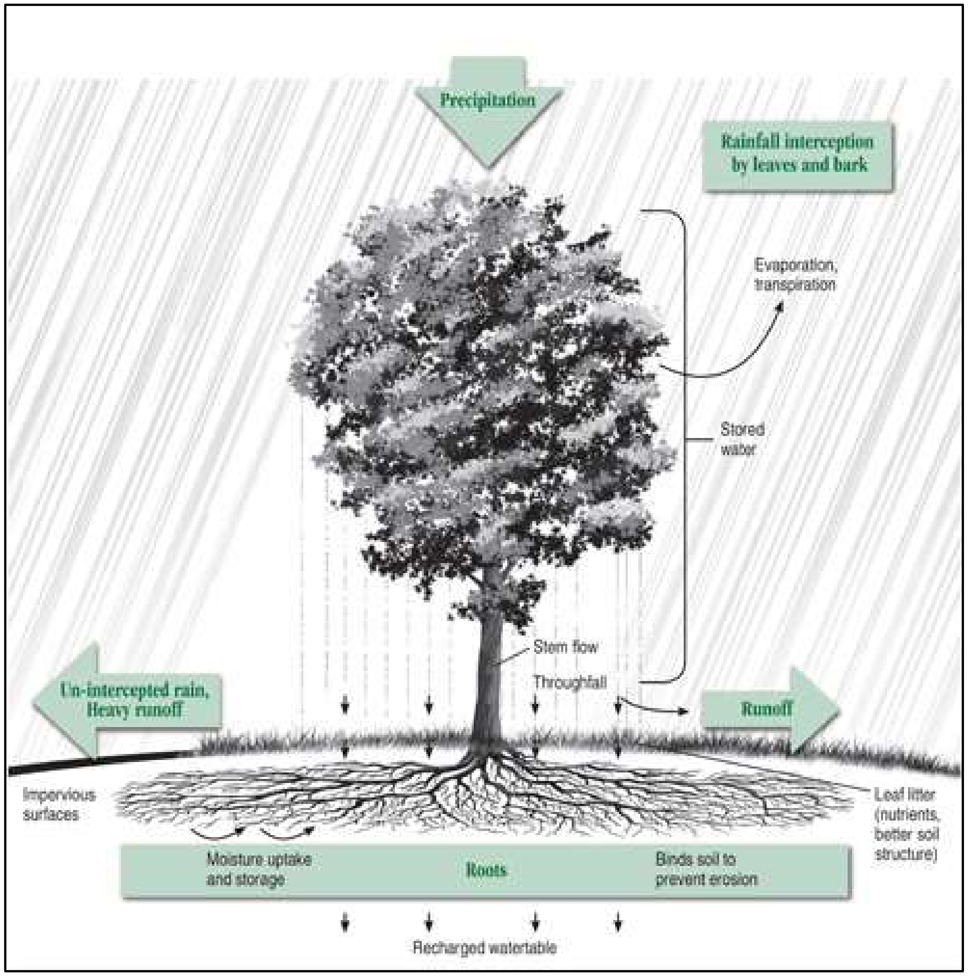
Benefits of Watershed Reforestation

Reduction of Stormwater Runoff: Enhanced infiltration and water retention.
Improvement in Water Quality: Filtration of pollutants through vegetation.
Biodiversity Enhancement: Creation of habitats for various species.
Climate Regulation: Carbon sequestration and microclimate stabilization.



Mechanisms of Stormwater Runoff Reduction

Infiltration Increase: Trees and plants improve soil structure, increasing water infiltration.
Transpiration: Water uptake by plants and subsequent release into the atmosphere.
Soil Stabilization: Roots bind soil, preventing erosion.



Source: treecanopybmp

Research Findings (1)

Hydrological response: urban area, watershed, soil erosion

Reforestation and Runoff Reduction in Urban Areas:
Study: "The Effectiveness of Reforestation in Mitigating Urban Runoff"
Findings: Reforested urban areas showed a 25-30% reduction in stormwater runoff compared to non-reforested areas. This reduction is attributed to increased infiltration and interception by tree canopies.
***Reference**: Smith, J., & Brown, L. (2018). Urban Forestry & Urban Greening, 34, 34-41.*

Impact of Reforestation on Watershed Hydrology:
Study: "Hydrological Response to Reforestation in Watershed Management"
Findings: Watersheds that underwent reforestation experienced a significant decrease in peak flow rates during storm events, reducing the risk of flooding. The study reported a 40% reduction in peak flow rates in reforested watersheds.
***Reference:** Liu, C., & Zhang, X. (2016). Journal of Hydrology, 540, 48-58.*

Long-Term Benefits of Reforestation:
Study: "Long-Term Effects of Reforestation on Soil Erosion and Runoff"
Findings: Over a period of 20 years, reforested areas showed a sustained decrease in soil erosion and surface runoff. The study highlighted a 50% reduction in soil loss and a 35% reduction in runoff.
***Reference:** Johnson, P., & Wilson, M. (2017). Environmental Management, 59(3), 442-455*

Research Findings (2)

Interception Rates: Vary significantly across different forest types

Coniferous Forests:
Interception Rate: High, often exceeding 35%.
Research: "Rainfall interception in a mature Sitka spruce forest" showed interception rates of around 35-45%, influenced by needle structure and canopy density.

***Reference**: Gash, J.H.C., & Morton, A.J. (1978). Journal of Hydrology, 38(3-4), 173-189*.

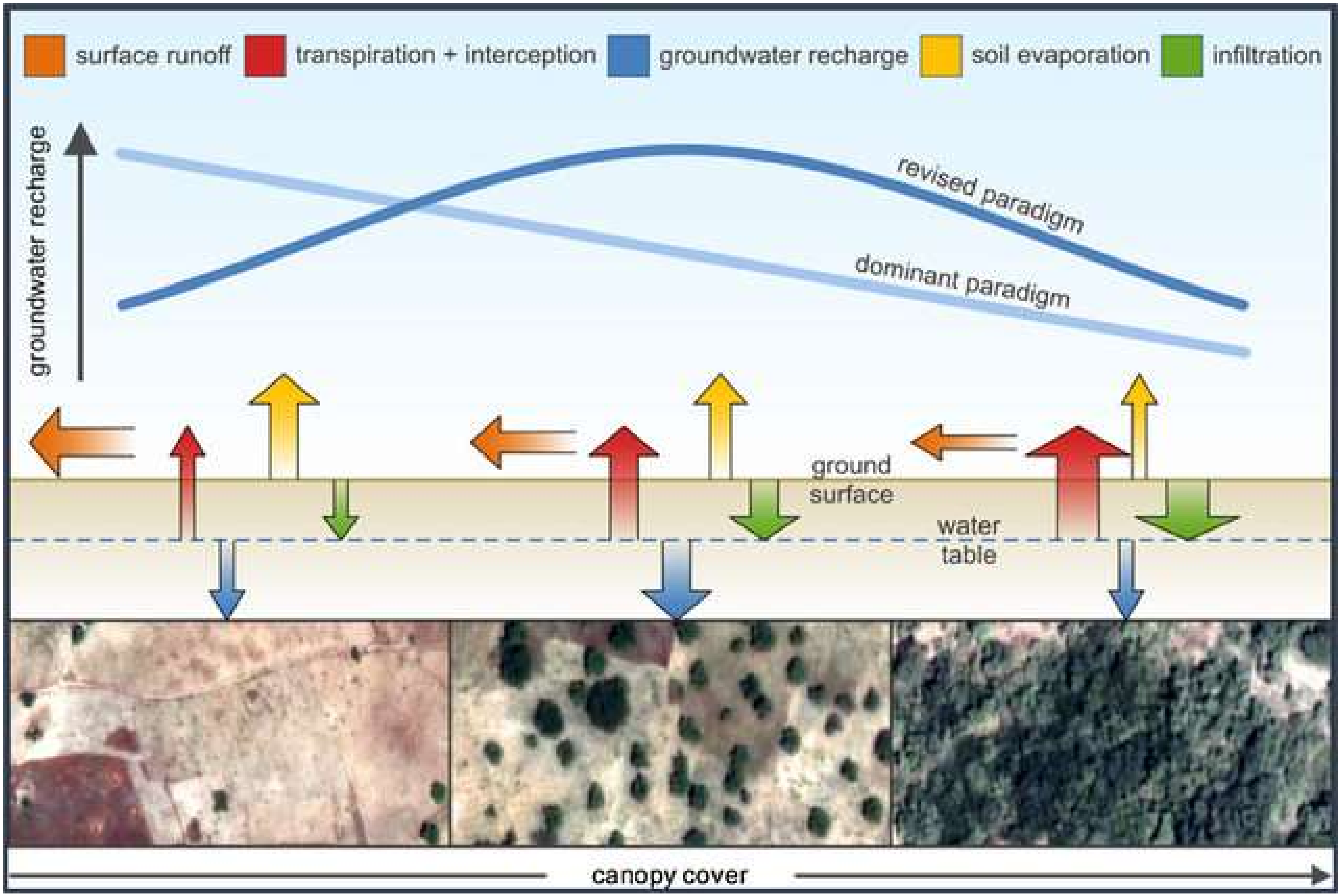
Mixed Forests:
Interception Rate: Variable, depending on the proportion of tree types.
Research: "Comparative interception loss in mixed and pure forest stands in Europe" highlighted interception rates ranging from 25% to 40%, depending on species composition.

***Reference**: Llorens, P., & Domingo, F. (2007). Hydrology and Earth System Sciences, 11(3), 729-741.*

Mediterranean Forests:
Interception Rate: Typically lower, around 15-25%.
Research: "Interception loss in Mediterranean forests during dry and wet seasons" indicated lower interception due to sparse canopies and seasonal leaf drop.

***Reference**: Garcia-Estringana, P., & Latron, J. (2010). Agricultural and Forest Meteorology, 150(4), 554-565.*

Research Findings (3)



Research Findings (4)

Hydrological response: simulation

Research Findings (5)

Comparative soil water retention: organic matter, deforestation

Studies indicate forest soils retain 10-30% more moisture than non-forested soils, due to their superior structure and organic content.

Research: "Comparative Analysis of Soil Moisture Retention in Forested and Non-Forested Areas" showed that forest soils have significantly higher moisture retention.

***Reference**: Brown, K., & Anderson, L. (2017). Journal of Soil Science, 62(2), 345-356.*

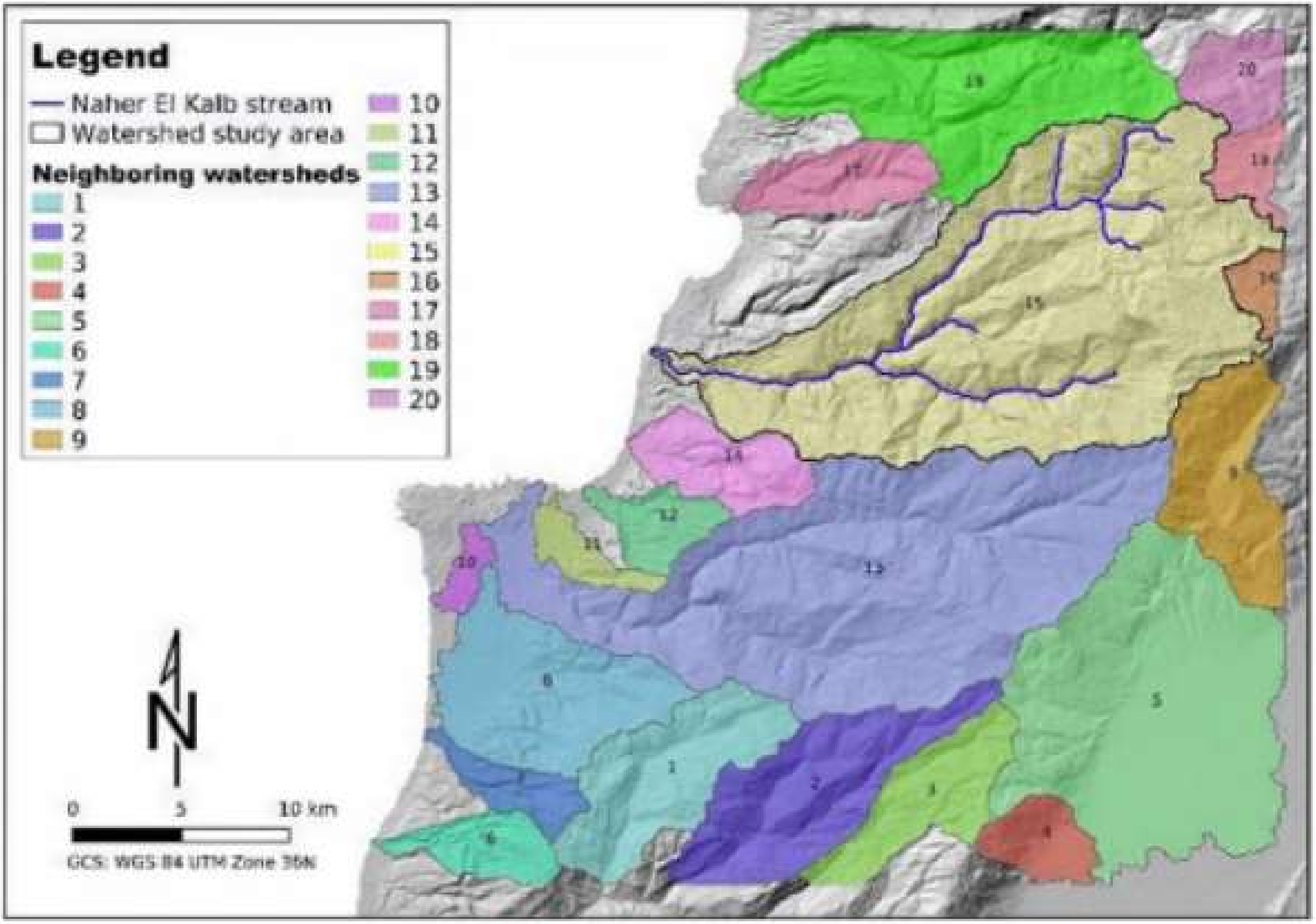
Impact of Disturbances

Deforestation, forest fragmentation, and land-use changes can negatively affect soil structure, reducing moisture retention and affecting water availability downstream.

Research: "Impact of Deforestation on Soil Moisture and Hydrology" found that deforested areas have significantly lower soil moisture retention.

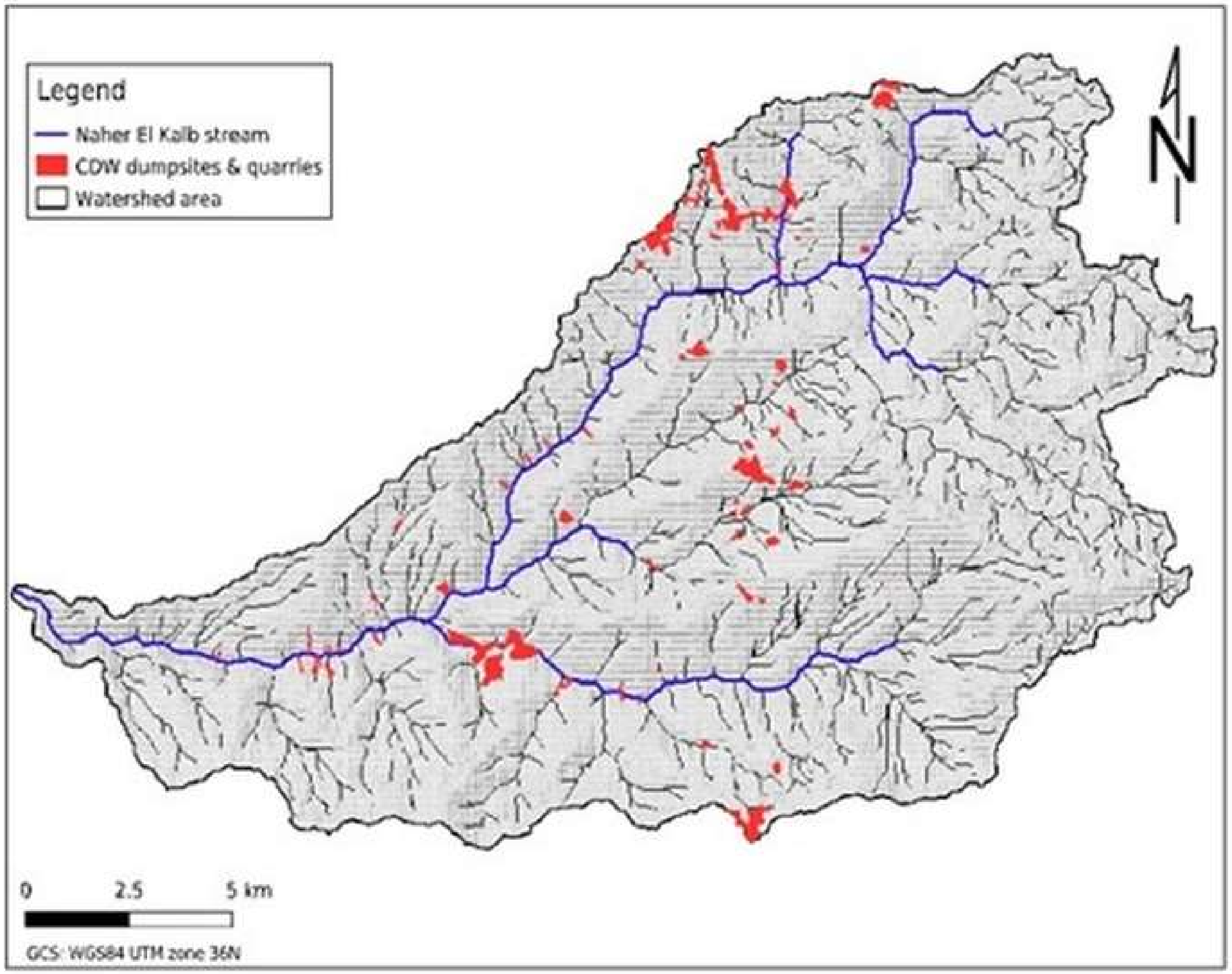
***Reference:** Wilson, R., & Black, P. (2016). Environmental Research Letters, 11(9), 094021.*

Case study 1: Spatial distribution and landscape impact analysis of quarries and waste dumpsites*



*Reference: Mitri, G., Nasrallah, G. & Nader, M. Spatial distribution and landscape impact analysis of quarries and waste dumpsites. Environ Dev Sustain 23, 12302–12325 (2021). https://doi.org/10.1007/s10668-020-01169-z

- A watershed map comprising location of quarries and CDW dumpsites was created.
- It was observed that most of CDW dumpsites and quarries were located close to the different river streams of the watershed.
- At the watershed level, quarries occupied a total area of 3,096,910 m2, while CDW dumpsites occupied an area of 378,515 m2



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The NRCS-CN model (USDA 1986; Zhang 2019) was adopted to estimate changes in water runoff volume as a result of converting a natural landscape to existing quarries and CDW dumpsites. According to Fan et al. (2013), the NRCS-CN model is mostly used for runoff estimation in watersheds lacking monitoring stations (Fan et al. (2013)).

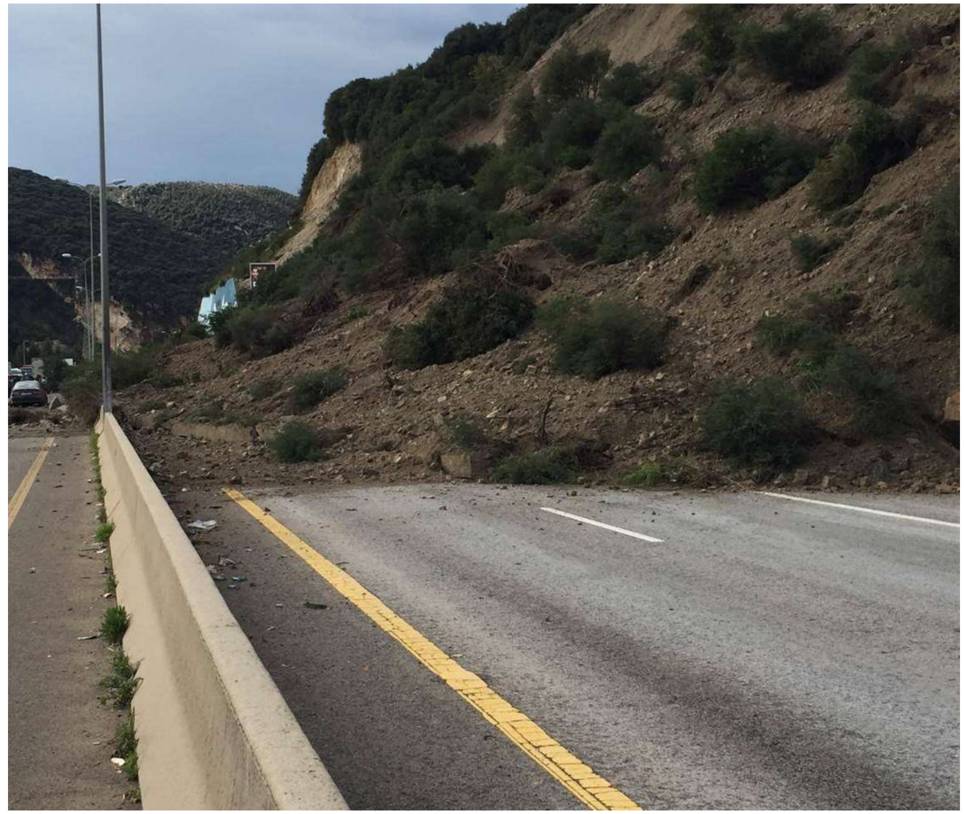
- The assessment of annual runoff volume resulting from the natural state of the quarrying and CDW sites before conversion was estimated at **1,202,753 m3**.

- Also, the assessment of annual runoff volume resulting from the quarrying and CDW sites after conversion was estimated at **1,647,351 m**3 (i.e., 27% of increase in annual volume runoff).

- This increase in runoff volume was mainly affected by sites converted from forest (i.e., 27%), grassland(i.e., 18%), cropland (i.e., 10%) and natural land with little vegetation (i.e., 8%) to quarries and CDW dumpsites.

**Reference: Mitri, G., Nasrallah, G. & Nader, M. Spatial distribution and landscape impact analysis of quarries and waste dumpsites. Environ Dev Sustain 23, 12302–12325 (2021). https://doi.org/10.1007/s10668-020-01169-z*

Case study 2: Identification of sites for post-fire restoration and rehabilitation work
From Assessment to local intervention



Study Findings (Valkanou et al., 2022):

- Pre-fire, the soil erosion potential in a forested area was mainly negligible to low.
- Post-fire, moderate and high erosion potentials increased significantly
- Maximum soil loss (in t/ha/year) rose by 86%, and mean soil loss potential increased by 114% post-fire

**Reference: UNDP-Land Degradation Neutrality Project in Jbeil and Akkar (2024)*

Mapping steps

dNBR from sentinel-2A	Severity classes
0.1 - 0.27	Low severity
0.27 - 0.44	Moderate Severity
0.44 – 0.66	High severity
>0.66	Very high severity

	Slope gradients (degree)		
Risk 1	**0 - 10**	**20.**	**>20**
Low	Low	Moderate	Moderate
Moderate	Moderate	Moderate	High
High – Very high	Moderate	High	High

	Final degradation risk		
Soil texture	**Low**	**Moderate**	**High**
Clay	Low	Moderate	Moderate
Sandy	Low	Moderate	Very high
Sandy Clay	Low	Moderate	High
Sandy Silt	Low	Moderate	High
Silt	Low	Moderate	Moderate

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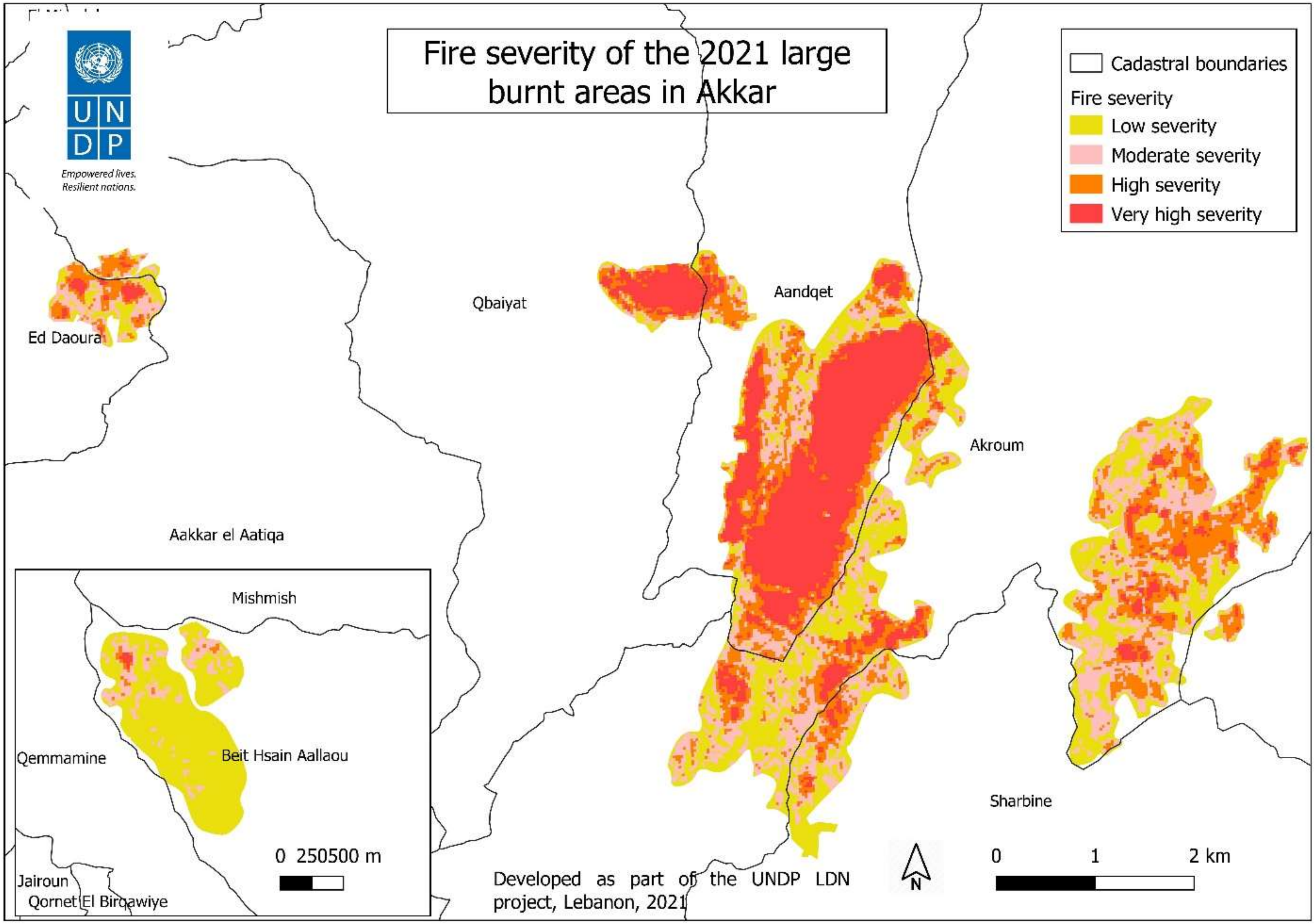
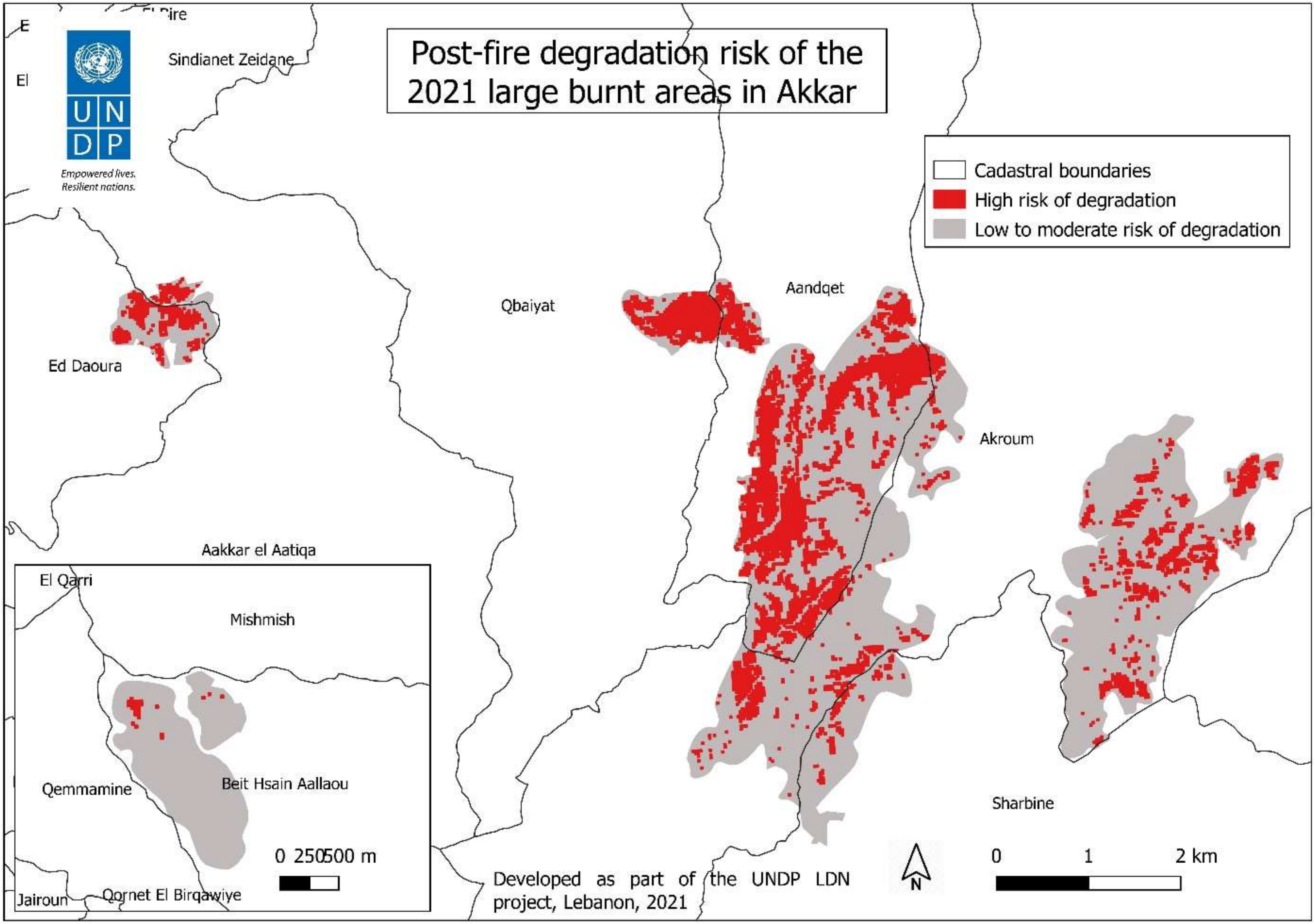
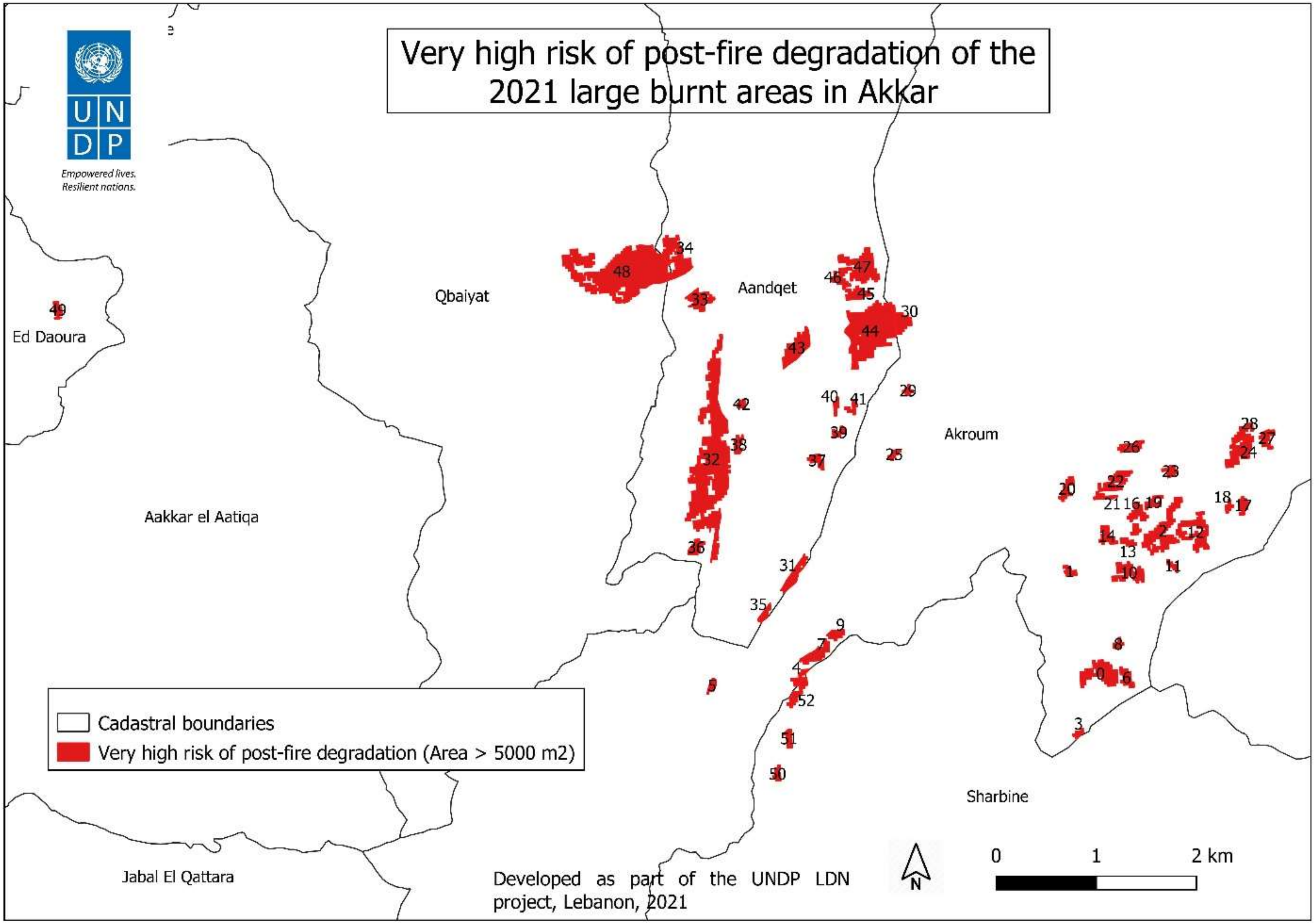
Step 1: Fire severity map



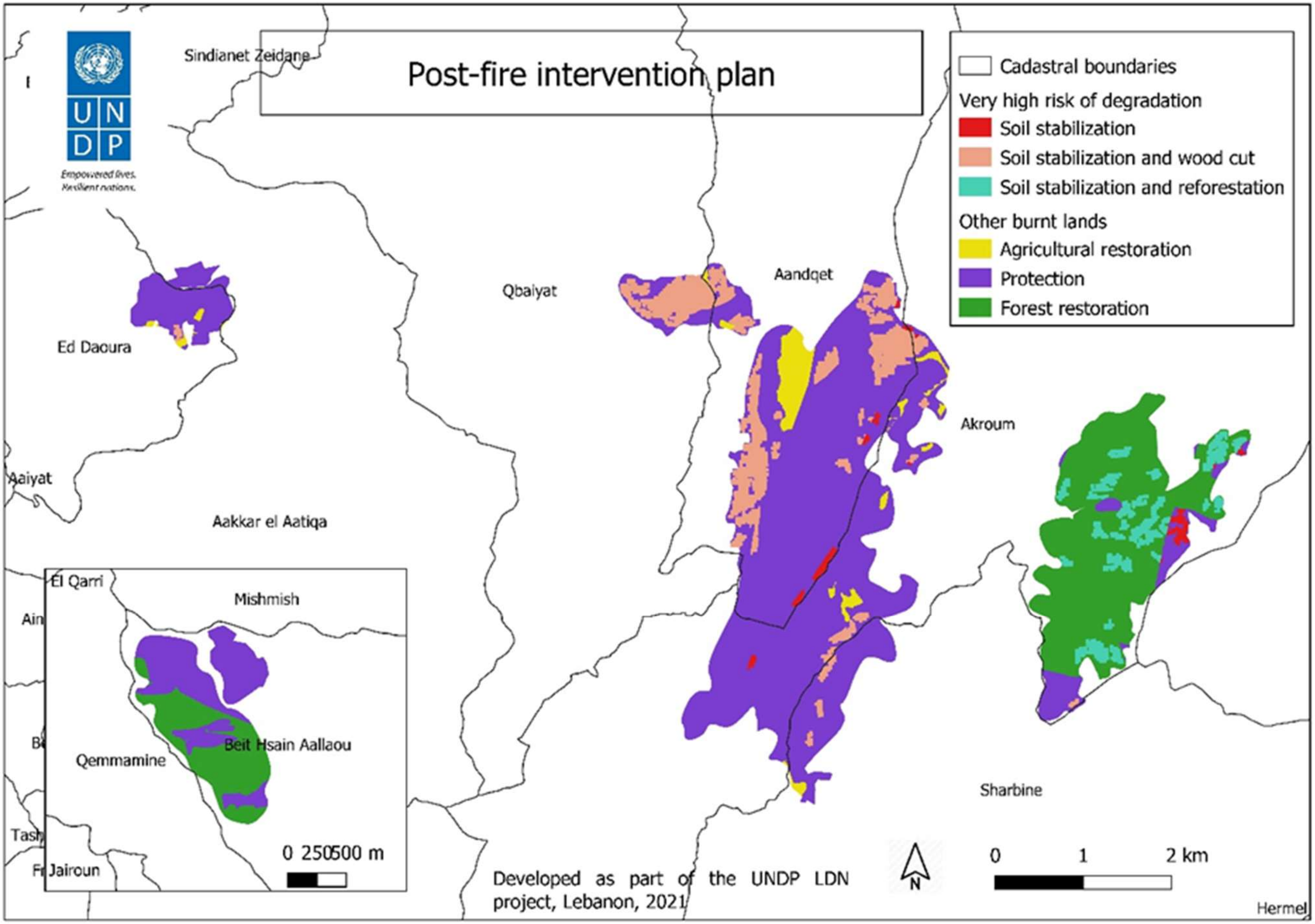
Step 2: Risk of degradation



Step 3: Field visits and prioritization



Step 4: Post-fire intervention



Post-fire intervention: Pilot site in Akkar Attika - Lebanon

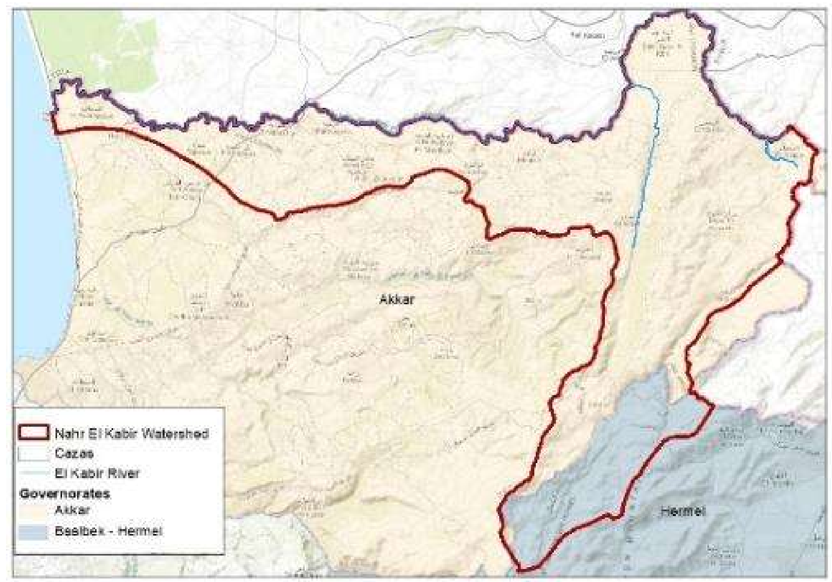
Estimated total volume of collected soil over **1 ha= 433 m3** !!! Supporting natural vegetation recovery

Case study 3: Vulnerability Assessment in the water sector of **Al Kabir river basin** in Lebanon*

**Reference: United Nations Economic and Social Commission for Western Asia (ESCWA), Arab Center for the Studies of Arid Zones and Dry Lands (ACSAD), Ministry of Energy and Water of Lebanon and Food and Agriculture Organization of the United Nations (FAO). 2022. Climate-proof watershed management design and resilience package: Nahr el Kabir basin. RICCAR technical report, Beirut.*

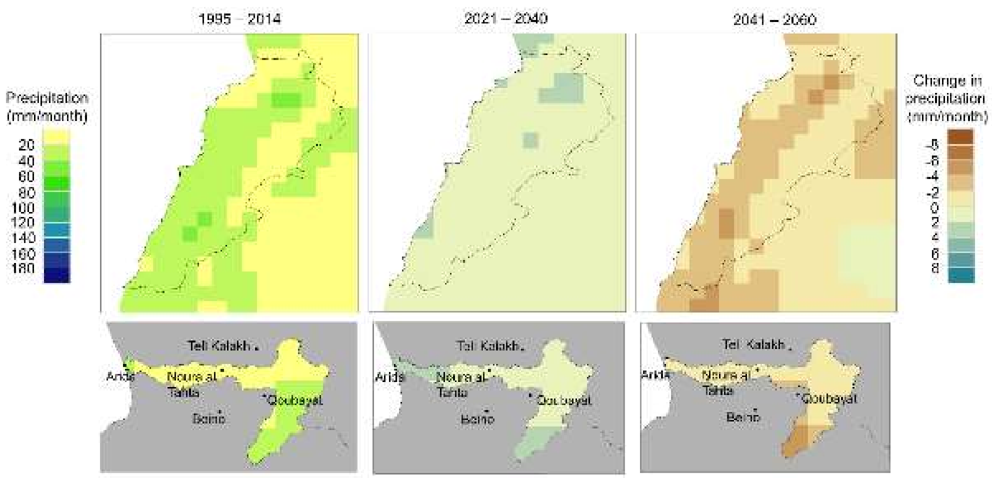
Study Area Description: the watershed

- Situated on the northern boundary of Lebanon
- The river rises from numerous karstic springs to the east and flows westward traversing a basaltic central plateau then meandering through the extensive alluvial flatlands of the coastal Akkar out to the Mediterranean Sea over an approximate distance 78 km including the Es-Safa tributary.
- The total watershed area is 954 km2, of which 26% (approx. 294 km2) is located in the Lebanese side.
- The scope of this work is limited to the Lebanese side of the basin.

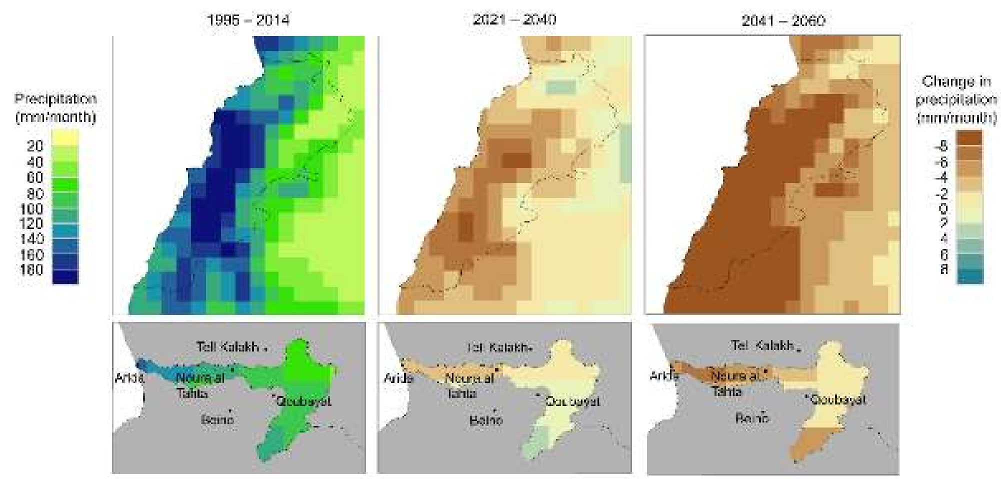


Location of the study area

Study Area Description: seasonal change in **precipitation** (9)

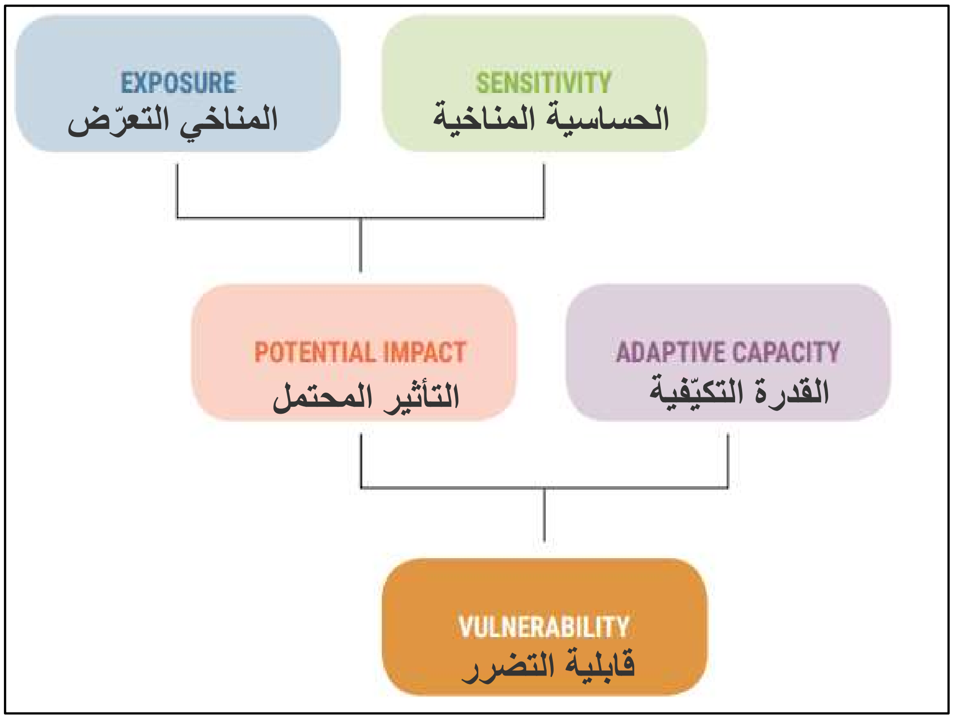


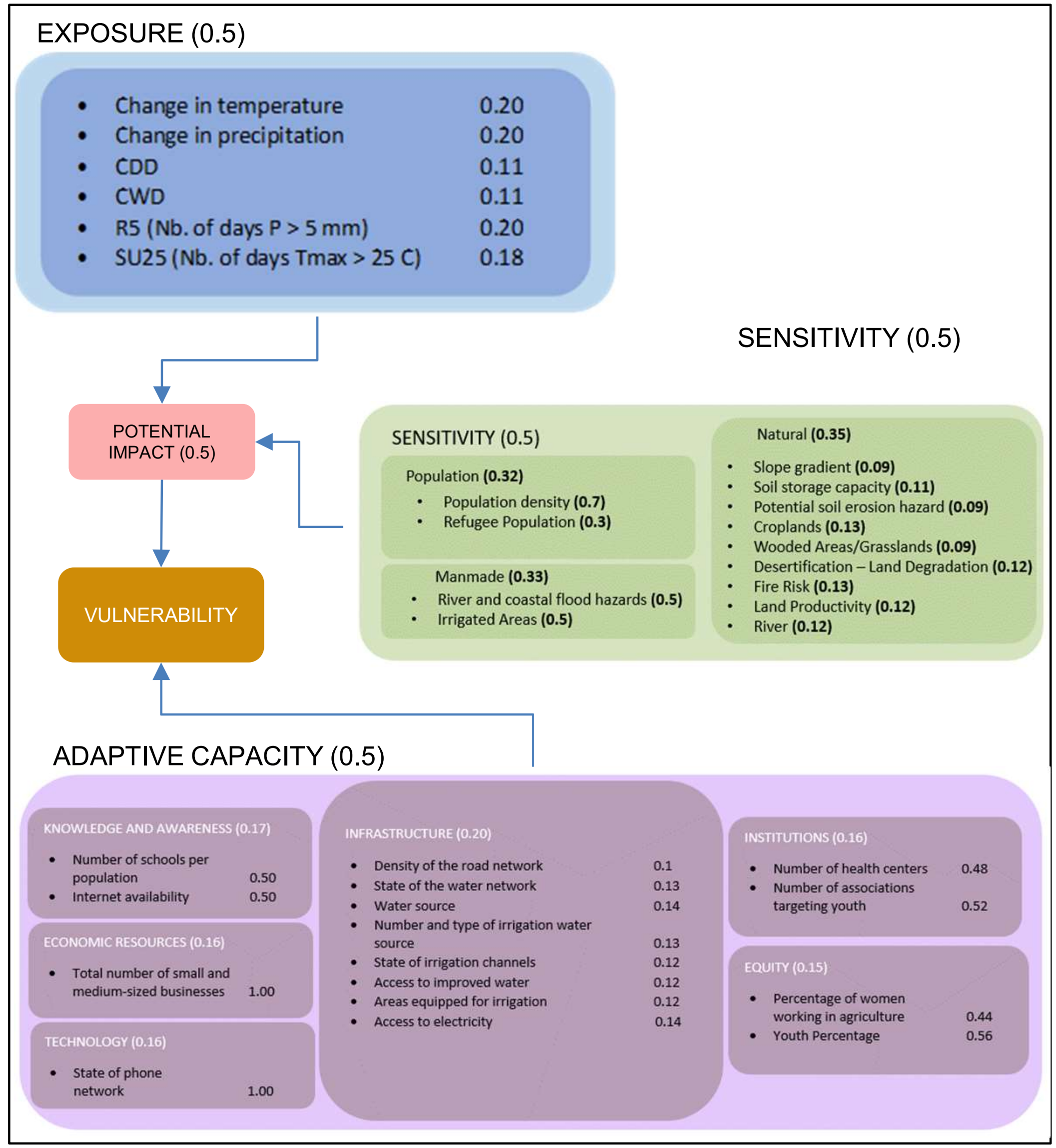
Seasonal change in precipitation (April-September) compared to the reference period based on an ensemble of six downscaled global climate models for the Mashreq Domain, SSP5-8.5



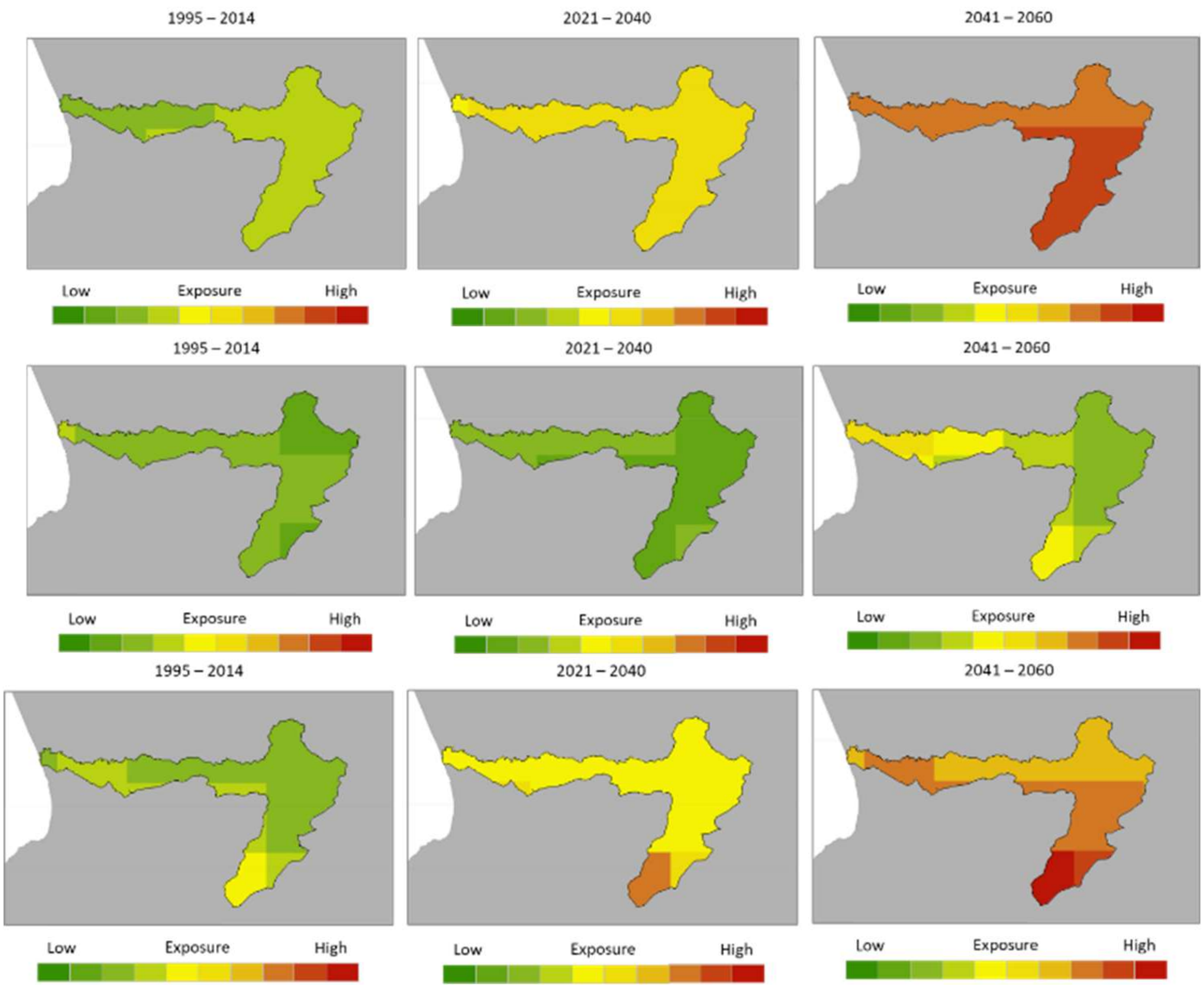
Seasonal change in precipitation (October-March) compared to the reference period based on an ensemble of six downscaled global climate models for the Mashreq Domain, SSP5-8.5

Impact chain





Exposure indicator maps (1)

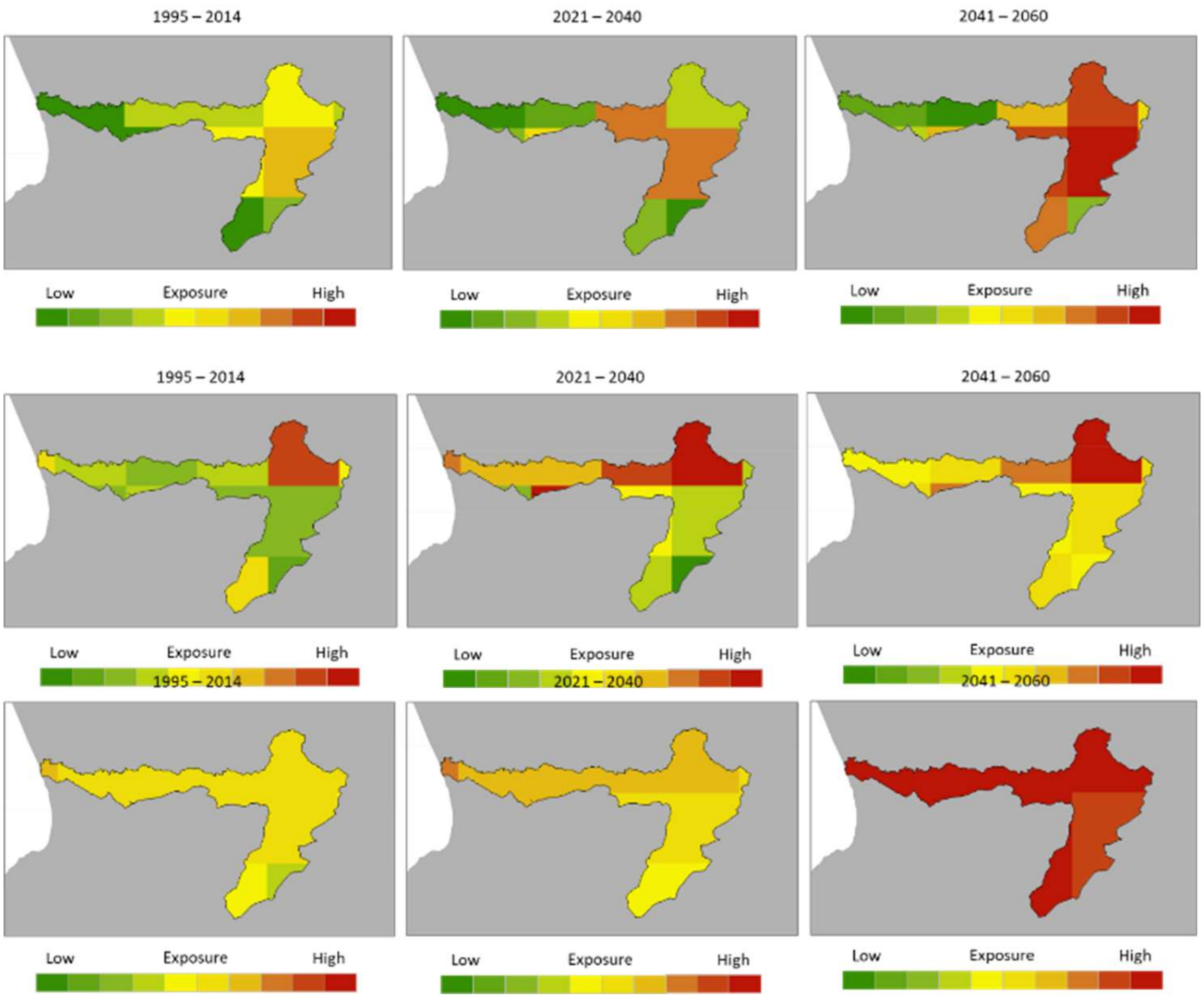


Change in temperature

Change in precipitation

Change in Summer Days

Exposure indicator maps (2)

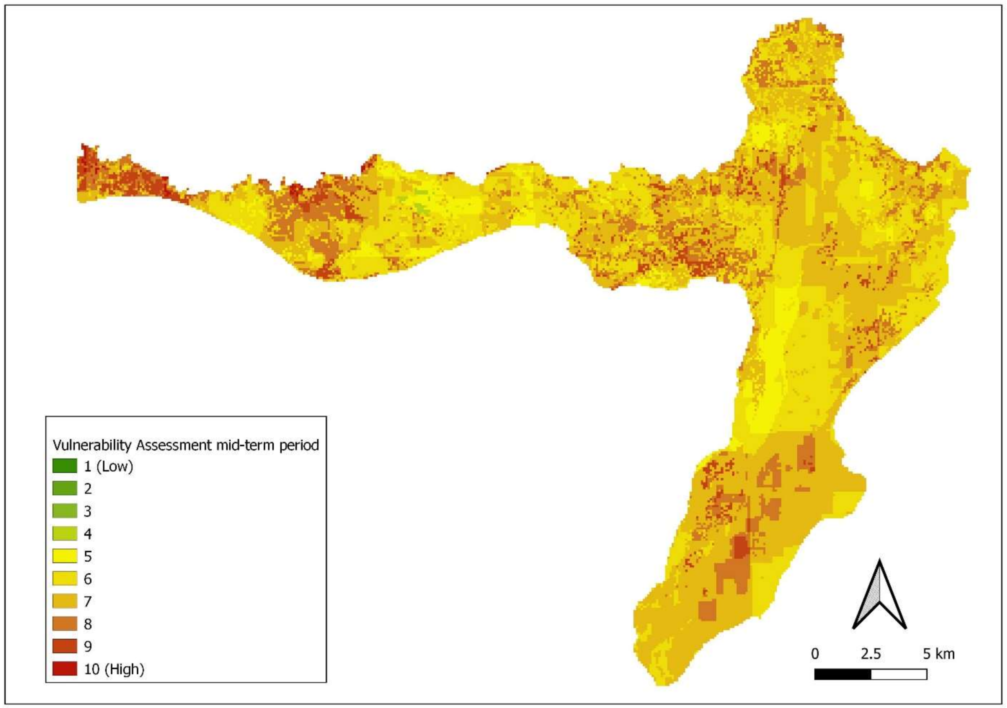


Change in Consecutive Dry Days

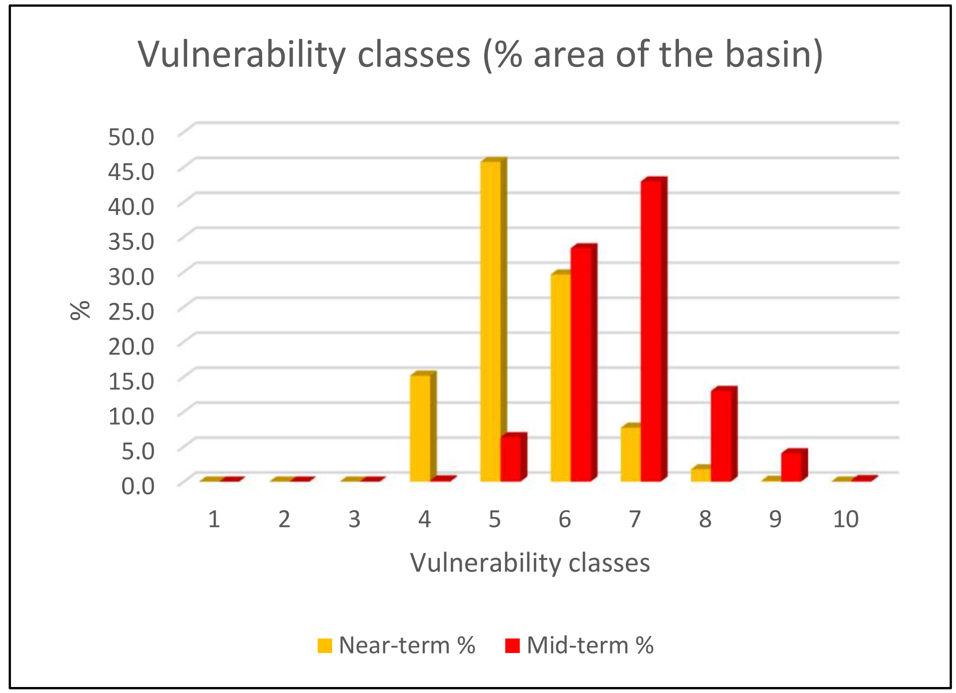
Change in number of Consecutive Wet Days

Change in Number of Precipitation Days

Vulnerability Assessment composite indicators



Mid-term period



Percent distribution of vulnerability classes in near-term and mid-term periods

Identified Climate-proof watershed management design and resilience package

Response to reduced water availability	Adapt to climate change in the Al Kabir river basin by establishing traditional water storage systems such as hill lakes, small dams and water ponds.
	Manage and utilize water and related natural resources sustainably and, in doing so, alleviate poverty and improve livelihoods.
Response to reduced water quality	Provide multi-purpose green infrastructure (a series of constructed wetlands) for water pollution control.
	Provide incentives to reduce water pollution from the source.
Response to drought and land degradation	Facilitate drought risk adaptation in a changing climate through rural land use management
	Apply a set of mitigation and adaptation strategies to combat land degradation and drought.
Response to disasters	Undertake a fuel treatment program to promote resiliency and reduce wildfire hazard.
	Undertake post-fire restoration activities to stabilize soil and reduce soil erosion and flash floods on fire affected sites.
	Establish functioning flood plains, ditches, inland wetlands, stream beds and banks to slow and attenuate floodwater.
Capacity building, knowledge and management	Strengthen water resources management and governance framework in the context of climate change.
	Improve knowledge management in the water sector at the basin level.

Challenges and Opportunities

- **Common Challenges in Watershed Reforestation**: Funding, maintenance, and community involvement.
- **Opportunities for Improvement and Expansion:** Technological innovations and policy support.

Policy and Funding

- **Importance of Supportive Policies**: Legislation and regulations that promote reforestation.
- **Examples of Successful Policies:** Case studies of effective policy implementation.
- **Funding Opportunities and Resources:** Grants, donations, and government programs.

Future Directions

- **Innovative Techniques and Technologies**: Use of drones, satellite monitoring, and advanced planting methods.
- **Potential Areas for Future Research**: Long-term impacts of reforestation on climate and hydrology.

Thank you

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