Transboundary Climate Risk in the Euphrates and Tigris Basin

Outline

The following presentation is the summary of a full analysis of transboundary climate risk for the Euphrates-Tigris Basin (ETB) region, delivered as a report for UNEP under Contract No. UNEP/2019/008 (4700016597) (Cornforth et al. 2023).

Tigris River at Hasankeyf, Türkiye. Source: National Geographic

1. Background
2. Methodology
3. Historical hazards and observed climate and environmental changes
4. Future climate projections
5. Climate storylines
6. Environmental and socio-economic impact narratives
7. Headline adaptation options
8. Next phase

See Report section “Methods and Data”

2. METHODOLOGY

Walker Institute

Methodology

Survey of hazards and their impacts in the region and **past observed climate and environmental change**

Analysis of latest climate science and of 25km scale regional climate models under 3 RCP emission scenarios, including levels of confidence/uncertainty

Development of **climate storylines** to summarize the range of plausible climate futures

Qualitative analysis of climate change impacts - water, land resources, health, agriculture and livelihoods **– in representative livelihood zones** based on **“real world” field-based evidence**

Infographics and narratives to communicate storylines and their impacts, and to engage with stakeholders to enable action on adaptation

Report sections “Overview of ETB”, and “Observed climatic and environmental changes”

3. HISTORICAL HAZARDS AND OBSERVED CLIMATE AND ENVIRONMENTAL CHANGE

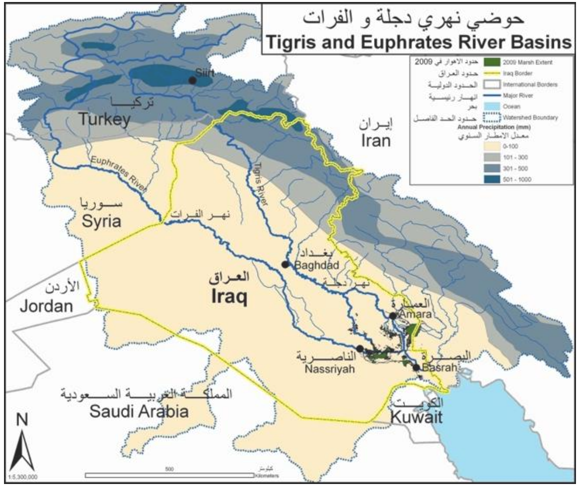
Overview of the region

The Euphrates and Tigris basin (ETB), at the heart of the West Asia region, supplies water to about 60m people for agricultural irrigation, energy production, domestic use, sanitation and overall economic development. Approx. 89% of the Euphrates river recharge, and 40-65% of the Tigris recharge, comes from winter rainfall and snow in Türkiye.

The ETB is **already exposed to climate change** through higher mean temperature and precipitation and extreme weather events (extreme heat, floods, droughts, sand and dust storms), and will be increasingly exposed to slow onset events (desertification, sea level rise). **Water availability (quantity and quality) is already a critical problem** given the naturally arid climate. This is exacerbated by the absence of agreed transboundary water coordination and management processes, suboptimal water and irrigation techniques, poor water infrastructures, and water pollution via sewage, agriculture and industry.

The region is **highly vulnerable economically** (high imports, low economic diversification, low productivity, system inefficiencies) **as well as socially** (conflict, internally displaced people, poor public services). A growing population poses additional pressure.

ETB annual precipitation



Source: UN (2010) Water Resources Management White Paper, UN Assistance Mission for Iraq, United Nations Country Team in Iraq, p. 20.

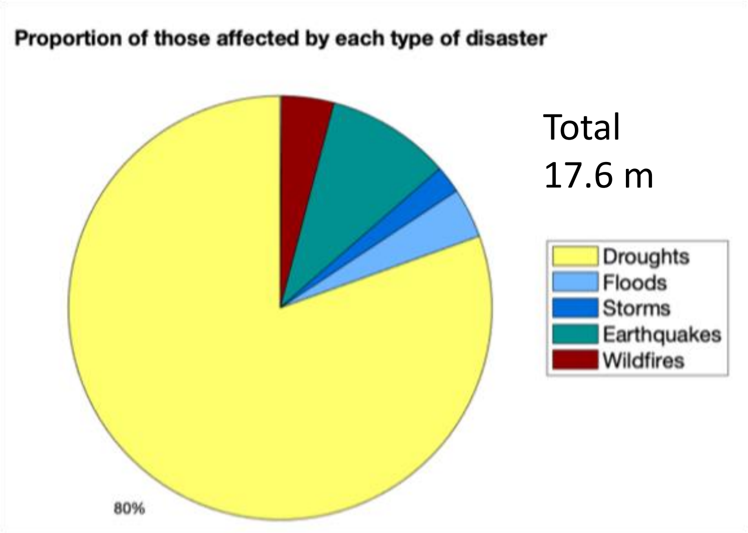
	Türkiye	Syria	Iraq	Iran
Contribution to Tigris	40-65 %	0 %	10-40 %	5-25 %
Contribution to Euphrates	89 %	11 %	0 %	0 %
Water dependency ratio (%) in 2017 (i.e. from other countries)	1.5 %	72 %	61 %	7 %

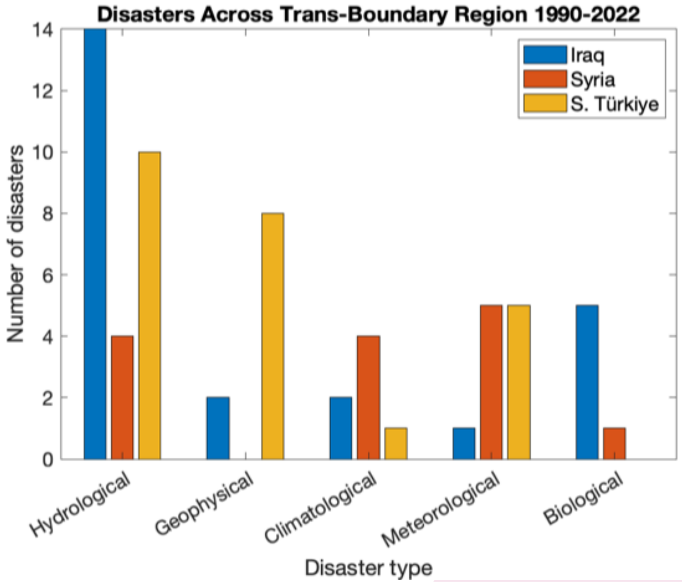
Source: ESCWA & BGR (2013) Inventory of Shared Water Resources in Western Asia. FAO Aquastat (2017).

Hazards affecting the ETB

Over 17.6 million people across the ETB region have been affected by a combination of environment-related disasters (1990-2022).

Climate-related risks are transboundary, especially those relating to water resources.





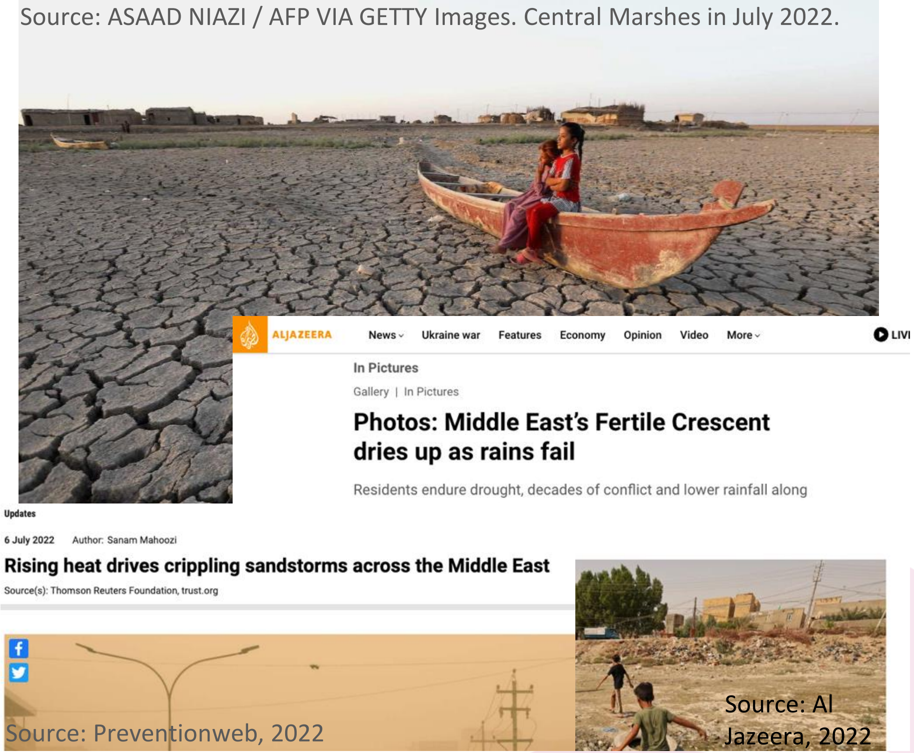
Data source: EM-DAT database. Figures in Cornforth et al. (2023)

Example: 2021-2022 drought in Syria and Iraq

Impacts

- 13.5 million people affected
- Wheat and barley crop failure for 40% farmers interviewed in north and south Iraq governorates
- Loss of livelihoods and higher food prices
- 20,000 people displaced in 10 Iraqi governorates due to water scarcity
- Outbreak of cholera in Syria linked to poor water quality in Euphrates
- At least 9 sand and dust storms in Iraq in 2022
- Flash floods after heavy rains on hardened soil
- Complexity of drivers: not just climate, but also land use and water resource management

Despite droughts being an historical feature of ETB climate, droughts are projected to become more frequent and more severe due to climate change.



Summary of observed changes in climate and the environment

	Dominant direct cause: Climate Change	Dominant direct cause: Other human interventions
Higher mean temperature (+1.5-2ºC) and max temperatures	✓	
More frequent and severe sand and dust storms, desertification Human interventions: Agricultural land and and water management (drying part of rivers/lakes)	✓	✓
Less precipitation in the northern ETB and earlier snowmelt	✓	
Loss of 30-50% Tigris and Euphrates rivers' flow in southern ETB Since 1970s. Human interventions: irrigation, dam operation upstream in all countries		✓
Depletion of groundwater Human causes: irrigation, domestic water use		✓

Report section “Future climatic changes”

4. FUTURE CLIMATE CHANGE

Recall there is uncertainty in climate models' outputs

1. Emission scenarios (RCP/SSPs)

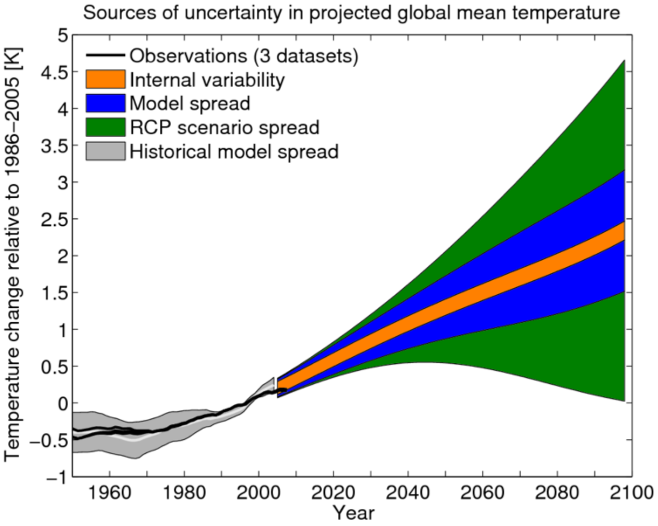
Source of uncertainty: How future society will be and how much GHG emissions will we emit?
Ineliminable and generally dominant.

2. Climate models are imperfect

Source of uncertainty : Climate models represent some aspects of the climate differently. Thus for same forcing they can show different results. **Can be reduced but scientific progress is slow, particularly for dynamic parts of the climate system which are poorly simulated (wind, circulation) (Shepherd, 2019)**

3. Internal climate variability

Source of uncertainty : The climate has natural cycles, like El Niño Southern Oscillation.
Ineliminable, but small and constant in time



Example of uncertainty in temperature projections.
Source: https://www.climate-lab-book.ac.uk/2013/sources-of-uncertainty/

Future climate change in ETB

	Models' confidence in stated direction of change	Magnitude of change depends mostly on
Higher mean, extreme temperature and heat stress	high	emission scenario
More sand and dust storms, droughts and widespread desertification	high	emission scenario
More erratic and strong rainfall events (flash floods)	high	emission scenario
Less precipitation in the northern ETB (linked to Mediterranean drying)	high	emission scenario and choice of models
More precipitation in southern ETB? (linked to potential shift north of tropical rain belt)	low	choice of models
Decline in Tigris and Euphrates rivers' flow. Sea level rise.	high	emission scenario and choice of models

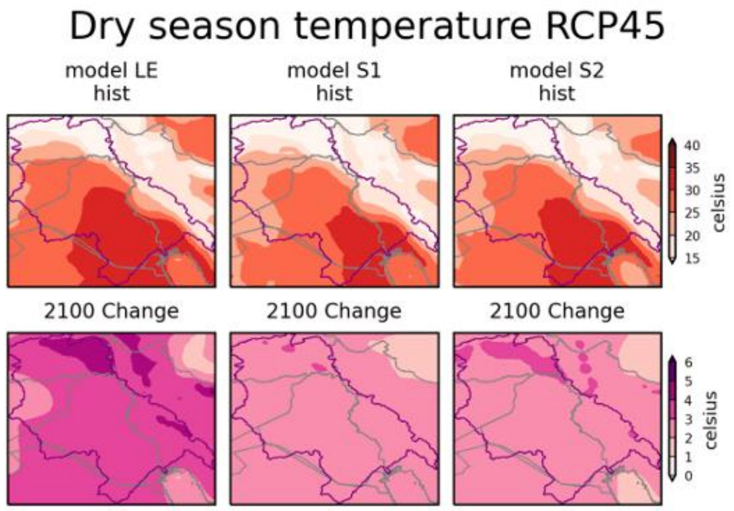
Example of climate model uncertainty

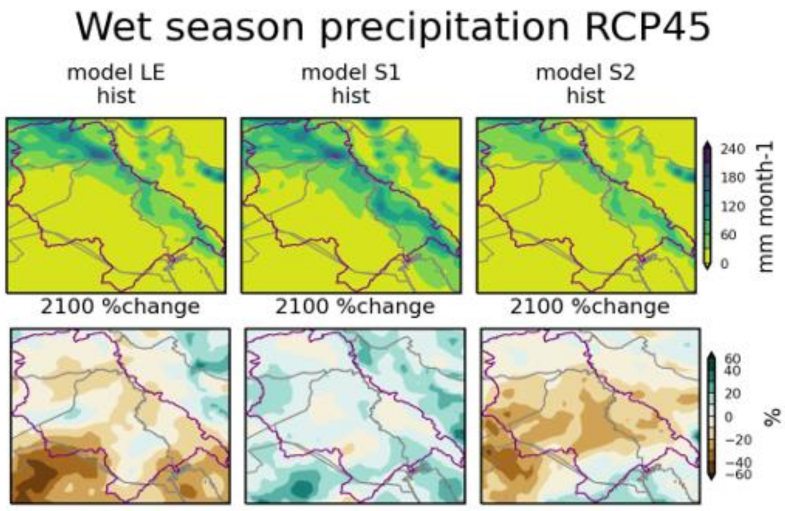
High confidence in direction of temperature change: all 3 models show hotter climate

Low confidence in regional direction of precipitation change: 2 models drier and 1 wetter.

Hist (1985-2005)

Change 2080-2100





Source: Three Regional Climate Models from CORDEX analysed for RCP4.5, selected to span the range of model uncertainty in CMIP5. Top row: historical (1985-2005) mean temperature in dry season. Bottom row: Change of 2080-2100 mean compared to the historical period. More details on this analysis in Cornforth et al. (2023).

Report section “Climate storylines in the TEB region”

5. CLIMATE STORYLINES

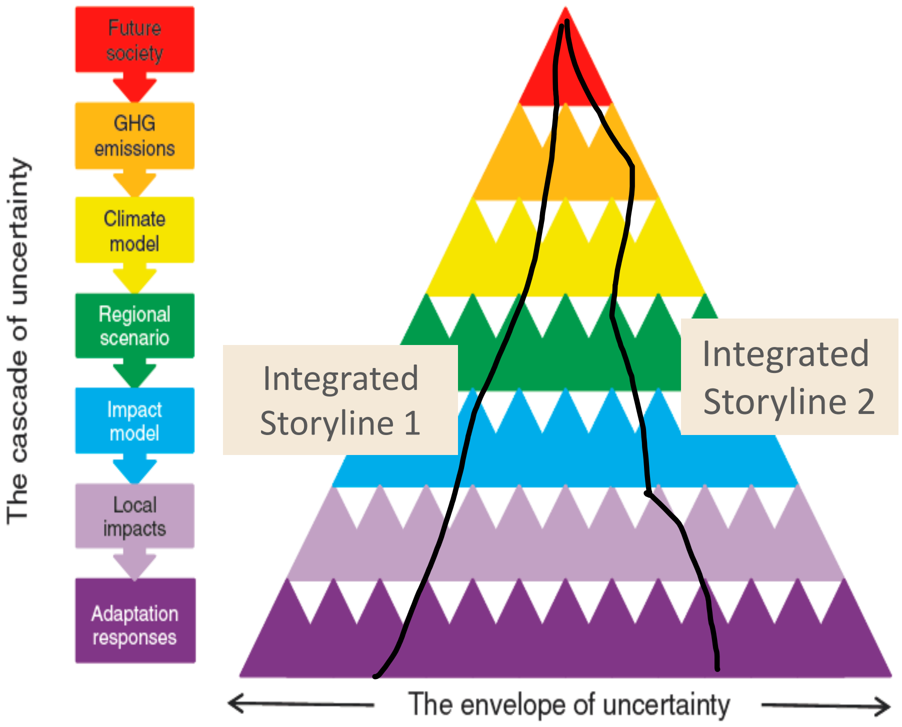
Climate storylines

The problem

- Direction and magnitude of changes in climate are crucial to understand for planning adaptation approaches and investments.
- But due to the imperfect nature of climate models and the ineliminable uncertainty of emission scenarios, there is uncertainty in direction and magnitude of change for various aspects of the ETB climate (see also slide 42 for details on climate uncertainty).
- **We need to grapple with a range of possible futures to design adaptation that is robust and flexible.**

The 3-pronged approach used in this study

1. Climate storylines, "plausible future events or pathways", are used to **summarize climate projection uncertainty** into a small number of plausible futures (Shepherd et al., 2018)
2. Assuming also specific land, water use and socio-economic scenarios, we develop integrated climate-environmental-socioeconomic storylines
3. **Associated narratives and infographics** are generated to translate this science into robust, actionable information for policymakers without losing critical quantitative information



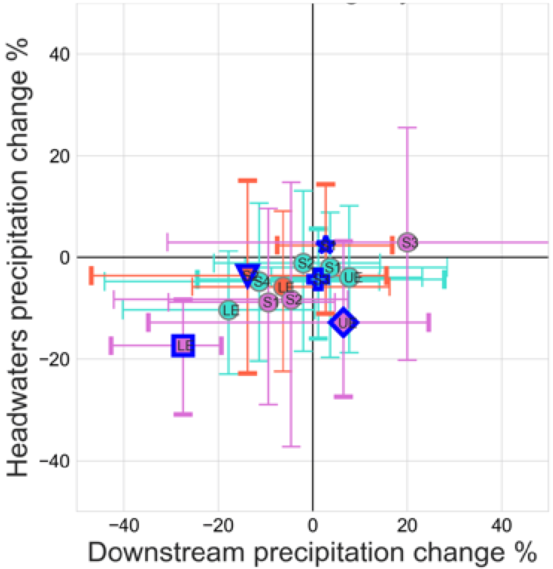
Source: Adapted from Wilby & Dessai (2010). **Black lines depict visually integrated storylines, represented as paths through the cascade of uncertainty**.

University of Reading

Climate storylines for TEB

- Focus on **three impact-relevant variables:** mean temperature across the ETB in wet and dry season, wet season precipitation in the north of ETB (crucial for recharge of rivers & aquifers) and wet season precipitation in the south ETB. Note wet season is defined as October to March, and dry season as April to September.
- Look **how the three variables change across emission scenarios** (3 RCP scenarios, 2.6, 4.5. and 8.5) **and models** (3-5 Regional Climate Models, spanning CMIP 5 model uncertainty for each RCP).
- Figures (a) and (b) are used to select models that span most of the uncertainty (highlighted in blue, total of 5).

(a) ETB wet season change by 2080-2100



(b) ETB wet season change by 2080-2100

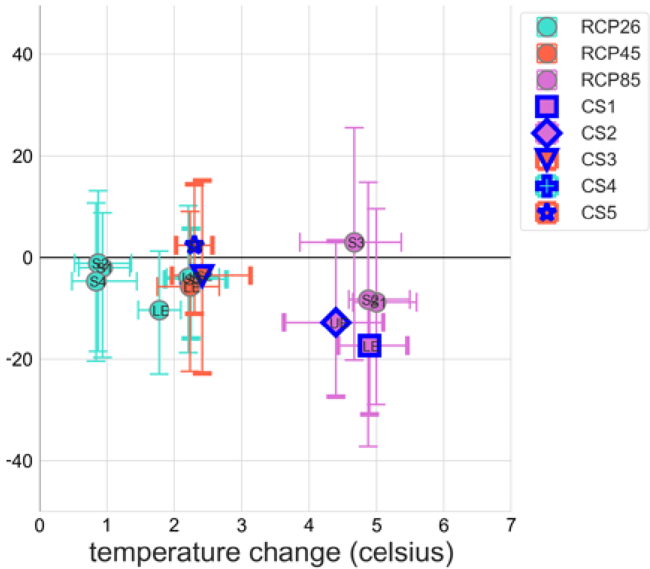


Figure (a) shows the relationship between north ETB precipitation and south ETB precipitation in wet season.
Figure (b) shows the relationship between north ETB precipitation and all ETB temperature change in wet season.

Climate storylines for ETB

- The 5 models selected via Figures (a,b) in the previous slides **constitute the 5 climate storylines for the ETB, summarized below.**

Climate storyline	Wet and dry season temperature changes	Wet season headwaters precipitation change	Wet season southern-Iraq precipitation change	Model
1	↑↑↑	↓↓↓	↓↓	RCP8.5 LE
2	↑↑↑	↓↓	↑	RCP8.5 UE
3	↑↑	↓	↓↓	RCP4.5 S2
4	↑	↓	no change	RCP2.6 S3
5	↑↑	↑	↑	RCP4.5 S1

- **Common aspects across the storylines:**
  - **Whole of ETB will be hotter**
  - **Northern ETB most likely drier**
  - **Decline in river levels is also very likely,** *because about 80% of rivers recharge comes from north ETB*
- **Differences:**
  - ***Southern ETB precipitation changes are unclear: drier and wetter scenarios both plausible*** *given the current knowledge and climate models projections.*

Report section “Climate, environmental and socio-economic risk narratives”

6. ENVIRONMENTAL AND SOCIO-ECONOMIC IMPACT NARRATIVES

For two livelihood zones in north-west Iraq (Ninewa and Anbar)

From natural and human pressures to local impacts

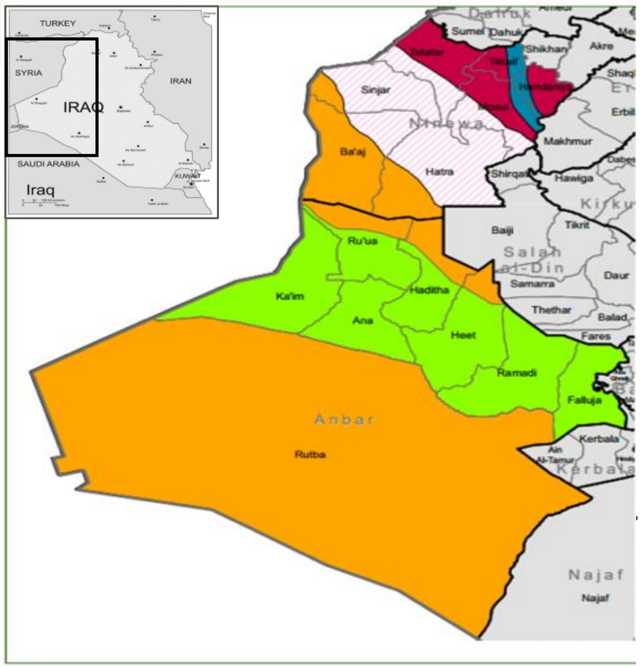
Tools for translating our understanding of climate science into impacts at local level

- **We focus on six sectors**: land resources, water resources, agriculture, livelihood, health, human mobility.
- **Human pressures are also considered:** current land use and water use trends, population growth, urbanization, no improved transboundary water cooperation (e.g., see table).
- **Qualitative analysis of impacts due to specific pressures are derived on literature and household-level economy study in two livelihood zones in North Iraq (Oxfam, 2019).** Note that we consider scenarios with no new climate adaptation in place.
- The Driver-Pressure-State-Impact-Response (DPSIR) framework is adopted **to systematically map climate and human pressures into impacts.** Specifically, the taxonomy for land and water developed by Lucas, et al (2022) adapting it to arid climate.

	Water resources pressures	Land resources pressures
Natural pressures (including climate change)	• *higher temperatures* • *reduced precipitation* • *Increased (potential)evapotranspiration* • *increased precipitation variability* • *floods* • *droughts* • *heatwaves*	• *desertification* • *droughts* • *frequent sand and dust storms* • *soil salinization* • *land degradation*
Human pressures	• *increased water demand for households and agriculture* • *groundwater over-exploitation* • *water pollution from waste, agriculture, oil and gas production* • *unmitigated competition with upstream countries*	• *population growth* • *internal displacement* • *urbanization* • *consequences of past conflicts* • *mismanagement and/or abandonment of agricultural and natural land*

Case study: two livelihood zones in north-west Iraq

Tools for translating our understanding of climate science into impacts at local level



Two Livelihood Zones in north-west Iraq, close to border with Syria, are selected for the impact analysis on the basis of:

1) availability of Household Economy Analysis Baseline data, and
2) they are representative of rural economies in the ETB.

Rainfed High Wheat and Barley Producing (Ninewa). Close to Tigris.

Irrigated Mixed Crop, Vegetables and Livestock (Anbar). Along Euphrates

Source: Oxfam (2019), Household Economy Analysis Baseline Assessment for Building Resilience – Ninewa and Anbar Governorates.

Climate and environmental changes for two storylines in north-west Iraq

Two of the five climate storylines (CS) are analysed for the LZs. CS3 and CS4 are chosen because, within an overall drying and warming of the northern ETB (where the LZs are), they represent two different but plausible magnitudes of change.

Climate Storyline for ETB Headwaters	Precipitation	Temperature	Heat extremes*	Other weather extremes *	River's discharge**
N. 3 **(Hotter and drier)**	-10% winter -15% summer	+2.5ºC winter +3ºC summer	Large increase in heat stress day (+40 days/year with HI>35ºC), + 40 days/year with max temp above 45ºC	Large increase in flooding, extreme precipitation, droughts, sand and dust storms	-20% annual
N. 4 **(Warmer and slightly drier)**	-5% winter -15% summer	+2ºC winter +2ºC summer	Moderate increase in heat stress day (15 days/year with HI>35ºC), + 25 days/year with max temp above 45ºC	Moderate increase in flooding, extreme precipitation, droughts, sand and dust storms	-10% annual

*Assumed changes to extreme weather events based on the climate change knowledge portal by the World Bank (2022).

**Assumed changes to headwater discharges based on the literature reviewed, in absence of hydrological modelling performed specifically for this report.

Environmental and socio-economic impacts, common across the two livelihood zones and storylines

Water resources: decrease in surface and groundwater water quantity and quality

Land resources: desertification, loss of biodiversity, more sand and dust storms

Agriculture: loss of productive land and decrease in water availability, loss of yields and livestock mortality

Health: heat stress, air pollution due also to SDS, water borne diseases

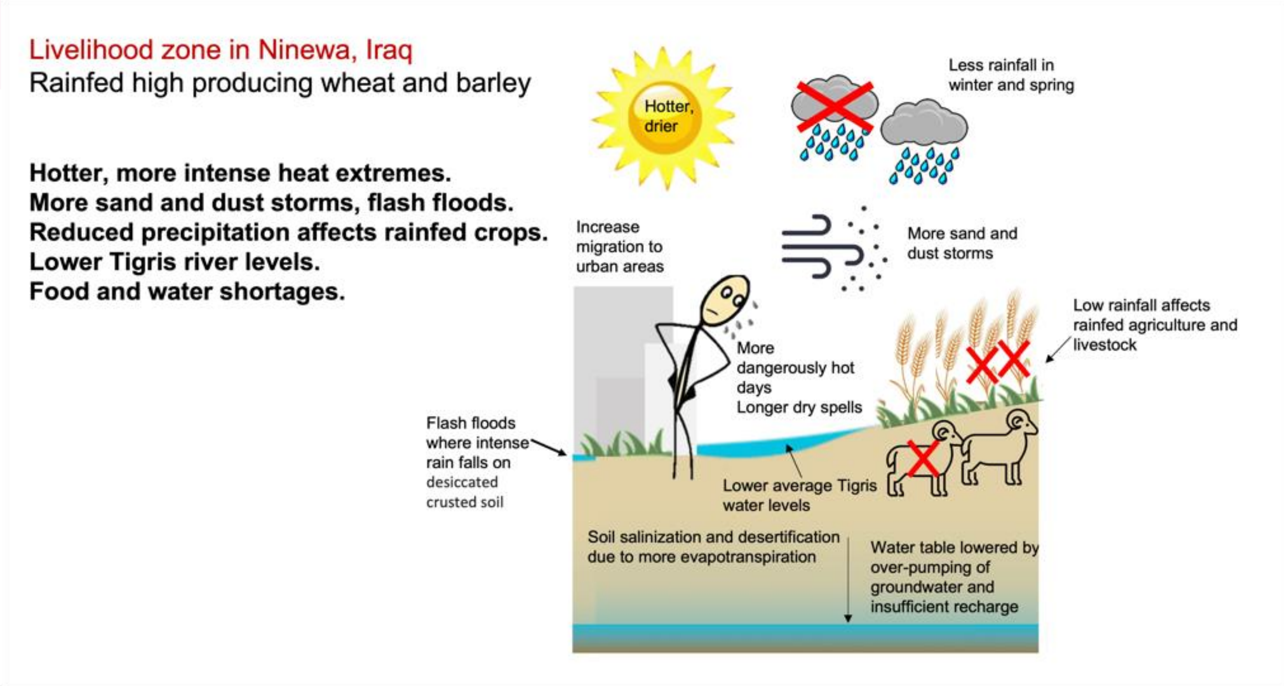
Livelihoods and human mobility: more rural to urban migration, women and children remain more in rural areas, loss of agriculture livelihoods, more rural poverty

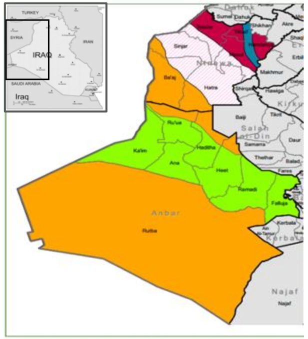
Energy: increase in energy demand in summer, heat stress affecting labour in energy plants.

Note that these impacts will be more pronounced for climate storyline 3 than for 4.

More details: Impacts for Ninewa Livelihood Zone

Infographics are used to explain and engage with a range of stakeholders to support adaptation planning





Rainfed High Wheat and Barley Producing (Ninewa) Close to Tigris.

Note that these impacts will be more pronounced for climate storyline 3 than for 4.

Environmental analysis underpinning the infographic for Ninewa LZ

Connecting natural and human pressures with likely impacts across six sectors

Natural pressures and their impacts

Type of pressure	Ninewa LZ Rainfed high producing wheat and barley		CS3: Hotter and drier/CS4: Warmer and slightly drier		
	Unmitigated environmental impacts (pressures)		Unmitigated social and economic impacts (pressures)		
	Land impacts	Water and air impacts	Population movement and livelihoods	Health	Agriculture and Energy
Natural pressures (including climate change)	Desertification (prolonged temperature and evaporation increase)	Tigris river discharge decreases **(-20% CS3 and -10% CS4)** (evaporation, reduced precipitation and snowfall) [estimate based on literature]	Rural to urban migration increases towards Mosul or towns across the LZ (loss of agricultural productivity due to environmental degradation)	Respiratory and eye diseases (air pollution due to sand and dust storm)	Decline in rainfed wheat and barley yield **(-20% CS3 and -15% CS4)** (increased temperature; heat extremes and evapotranspiration) [estimate based on literature]
	Cropland loss (increased soil aridity)	Groundwater decrease **(-20% CS3; -10% CS4)** (reduced precipitation, increased evapotranspiration) [estimate based on literature]	Increased poverty levels in rural areas (loss of agricultural employment)	Heat stress days (HI>35ºC) increase by **+400%in CS3 and + 150 % in CS4** (high temperatures; urban heat island (UHI) effect)	Further decline in wheat, barley due to water stress. **(- 10% CS3 and -5% CS4 rainfall;** SDS; occasional flooding)
	Increased sand and dust storms (bare soil exposure, erosion, drought, evaporation)	Water salinization and quality decrease (evaporation)	Loss of rural employment and wealth (loss of agricultural productivity due to environmental degradation; labour heat stress)	Waterborne diseases (water pollution; stagnant water due to reduced water in Tigris)	Decline in productivity of livestock (meat and milk) (increased temperature and heat stress; reduced fodder; SDS; occasional floodings)
	Erosion (topsoil removal, loss of vegetation cover)	Flooding (erratic excess rain, early spring snow melting)	Infrastructure abandonment in rural areas (loss of jobs, occasional high-risk flooding)	Re-emergence of diseases (change in water temperature, ecosystems changes)	Increased demand for energy in summer (extreme temperatures)
	Soil salinization (evaporation)	Blackwater event (inundation following extended drought)	Reduced season for construction work and cement production (heat stress)		Reduced demand for energy in winter (warmer winters)
	Vegetation species change (increased alkalinity e.g. due to drought, decreased nutrient supply in soil, invasive species, pathogens)	Air quality decrease (sand and dust storms)			
	Vegetation loss or dieback (sand and dust storms, drought, heatwave, water and soil salinization, reduction nutrients in soil, overgrazing, insect herbivory)				

Environmental analysis underpinning the infographic for Ninewa LZ (continued)

Connecting natural and human pressures with likely impacts across six sectors

Human pressures and their impacts

	Land impacts	Water and air impacts	Population movement and livelihoods	Health	Agriculture and Energy
Human pressures	Compaction (overgrazing stock, traffic / conflict)	Tigris water depth further decrease (reduced flow into Iraq from upstream Syria and Türkiye)	Urban densification and sprawl in and around Mosul (construction due to population growth and rural fluxes)	Malnutrition (reduced food availability)	Increased demand for energy (population growth)
	Desertification (abandoning of agricultural land)	Groundwater decrease (over-abstraction for agriculture and household use to mitigate for reduced water levels)	Urban social tensions (movement to urban areas due to loss of rural jobs; increased number of IDPs and pressure on urban services)	Respiratory diseases, cancer (air pollution due to oil production in the region around Mosul)	
	Bare soil exposure (lack of irrigation, or with poor quality irrigation water)	Water quality decrease (pollution from wastewater urban and rural; from oil and gas industries e.g., spiling)	Increase in PDS price and decrease in PDS delivered to people (decline in wheat production in this LZ, the 'green belt' of Iraq)	Diarrhea, cholera, dysentery, typhoid, and polio (drinking water polluted due to sewage management in overcrowded urban areas)	
	Cropland loss (farmland abandonment, agricultural loss, idle fallow rotation)	Air quality decrease (pollution from oil and gas industry)	Increase in poverty levels in rural areas (decrease PDS)		
	Soil salinization (irrigation with poor quality water)				
	Vegetation loss or dieback (pollution, urbanization)				
	Vegetation species change (grazing and overgrazing (stock), ground water extraction, pesticide application)				

Report section “Possible adaptation options”

7. HEADLINE ADAPATION OPTIONS

Water resources, land management, agriculture, livelihoods and health

Adaptation options

Despite uncertainty in climate projections and differences across the LZs, the following adaptation options might apply across the scenarios and regions:

Water resources: improve agriculture irrigation (uses 85% of total water); improve water infrastructure; fix leakages; sustainable use of surface and groundwater; ensure provision of environmental flows for biodiversity and ecosystem services; water pollution regulation and monitoring.

Land resources: combat desertification via planting species more resilient to heat/drought/salinity and new technologies (e.g. liquid nano clays).

Agriculture: drought tolerant wheat and fodder; better sowing techniques; pest and disease control; date pals rehabilitation.

Health: shift working hours to avoid heat stress; prevention of water-borne diseases; education

Livelihoods and human mobility: vocational skills in agriculture and construction; diversification of economic activities in rural areas.

Transboundary cooperation: dialogue on basin-wide water challenges and co-benefits of coordinated management (e.g. water and energy), share data and water management techniques. Note highly engineered system can buffer impacts of climate variability, delivering co-benefits with coordination.

Note on method: Options based on literature reviewed and limited national level engagement in Iraq. Adaptation analysis will be expanded in the next phase of work.

Summary of transboundary climate risk

Scientific consensus on climate change in the region will be characterized by

- **Higher temperatures** (+1.8ºC to 2.5ºC by 2050 under RCP4.5 or 8.5)
- **Less precipitation in headwaters and more year-to-year variability**
- **More intense and frequent extreme weather** (extreme heat, heavy precipitation, SDS)

Uncertainties remain largely on

- **precipitation change in southern TEB**
- **magnitude of all the above changes**

Climate change will likely be dominant cause of surface and groundwater decline, **outweighing role of water infrastructure and use.** e.g. -10 to -50% rivers discharge depending on models and warming levels

Without significant adaptation and reduction of current vulnerabilities, large impacts will be felt on

- **Land**: desertification, soil salinization, increased SDS, erosion
- **Water:** water quantity and quality decline (surface and ground), salinization, flooding
- **Ecosystems:** loss and/or change of species, soil erosion, water pollution
- **Livelihoods and agriculture:** cropland loss, reduced yields and livestock, invasive species
- **Health:** heat stress, water-born diseases, malnutrition, respiratory and eye diseases

Despite climate projection uncertainties, no-regret climate adaptation options can be identified to mitigate the above impacts, especially to address water scarcity, but locally-led stakeholder engagement is essential to understand what is, and isn't feasible.

Report section “Next steps”

8. NEXT STEPS

Next Phase: Applying Climate Change Risk Assessment for Enabling Adaptation Action

Objective

Help strengthen transboundary adaptation and decision-making processes via

- **Generating scientific** and analytical underpinning
- **Building capacity for adaptation planning** at national level, including a transboundary lens
- **Supporting dialogue** on approaches to climate adaptation that build resilience and trust

While the full scope and methodology are still to be agreed via consultation with UN Resident Coordinators, **potential outcomes** envisioned at this stage include:

- **Stakeholder consultations** using an adapted version of the Dynamical Adaptive Policy Pathways (DAPP) framework set out by Haasnoot et al.(2013). See https://walker.reading.ac.uk/project/2734/; slide 38)
- **Quantitative impact assessment and adaptation option** analysis for the region
- **Advancing transboundary adaptation planning** by providing technical support and convening relevant stakeholders at multiple governance levels when invited to do so

Given the challenges in adaptation planning (slide 37), an action **framework** for the Next Phase that will lead to the three outcomes is described in the following (slide 38).